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SOME FACTORS AFFECTING AGRICULTURAL PRODUCTION AND PRODUCTIVITY IN IRAQ INCLUDING SELECTED CLIMATE VARIABLES AND CROPS

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A Thesis submitted to the Social Science Faculty, University of Durham for the degree of Doctor of Philosophy.

June, 1982

SECTION FIVE

SECTION FOUR

CHAPTER TEN

WEATHER-CROP RELATIONSHIP: A GENERAL REVIEW

10.1 Introduction : Many factors affecting agricultural production and productivity in Iraq have been discussed in the previous Chapters. The effect of measures to improve agricultural production and productivity through the planned utilisation and/or modification of these factors does not seem to have been very significant.

Since agriculture is an open-air industry which very much depends not only on socio-economic and technical factors, but also on exoganous factors, in particular weather and climate (see Fig. 1.1), we must consider those factors as affecting agricultural productivity. First, we consider the relation between weather and agricultural productivity and secondly the degree to which this relation can be utilized to provide some valuable information to the agricultural policy maker at the national and regional levels and to farmers in farm management and decision making at the farm level. The need for such studies will be discussed later in this Chapter.

Weather affects agricultural productivity in two ways, first, directly through weather elements such as rainfall, temperature, etc., and secondly, indirectly in that weather may be a cause of spreading or limiting weeds, plant diseases and pests in the cultivated area in a particular season.(1) (The indirect effects through influencing soil characteristics have been examined earlier).

Traditionally, farmers in Iraq have only had a limited capability for protecting their crops from adverse weather conditions, apart from irrigation. Livestock can be given limited protection but field crops cannot, especially if dependent on natural precipitation. However, various farm practices can be employed to avoid or diminish the effects of adverse weather and it therefore becomes important to understand the nature of weather-crop relationships.

The aim of this Chapter is three fold : first, examining the need for weather-crop studies; secondly, discussing methods of analysing weather-crop relationship and thirdly, reviewing existing work on the subject in the context of this thesis.

10.2 The Needs for Weather-Crop Relationship Studies

Researchers for a long time have tried to study the relationship between agricultural crops and weather conditions. Usually, crops are represented by the final yield and weather is represented by a single factor or combination of factors. This relationship can be utilized in different ways, the most common uses being : first, in agricultural policy and farm management or decision making; secondly, as a sub-set or the set of variables in production function; thirdly, in forecasting (pre-harvest estimate) as well as the estimating of actual agricultural production; fourthly, in irrigation purposes; fifthly, in the possibility of estimating the cost of damage to production due to weather factors, and crop insurance.

The relationship between weather and future crop yields, the basis of production forecasting, has various economic, organisational and technical implications. For the government and government agencies, these include the organisation of transport and storage facilities at the right time to help to minimize losses due to e.g. pests, birds and unexpected weather conditions after the harvest and deciding annual pricing policy for a particular crop. The implications are particularly important for import and export policies, especially in a country like Iraq where the risk of crop failure, for example of wheat in the rainfed area, due to weather condition is very high. If it proves possible to establish reasonably precise constants to measure crop-weather correlations this may also provide useful indirect ways to check the accuracy of agricultural data which is collected by other methods.

An understanding of crop - weather relations is also important at farm level, since risks of harvest loss may be minimized by the appropriate application of improved methods of dry farming and the adoption of new technology. This,however,cannot be achieved without highly developed extension services and skilful farm management in both private and social sectors.

In all, we see without doubt the economic value of understanding weather-crop relationships.

10.3 Methods of Analysing Weather-Crop Relationship

Generally speaking,there are two major ways of analysing weather-crop relationships, the first one is the weather cycle approach, the second based on statistical analysis.(2) The emphasis on statistical technique to express weather-crop relationship will be used in this study. Nonetheless,a brief explanation of the weather cycle as a method which can be used to express weather-crop relationship will first be given.

10.3.1 Weather Cycle

This approach assumes that agricultural production or agricultural productivity will increase or decrease according to a particular weather cycle,such as sunspot incidence. This weather cycle varies in terms of length, time of occurrence and effects from one country to another.

Studying the weather cycle and its effects on agricultural production or productivity (production/cultivated area of certain crops) has long aroused a good deal of interest among economists, statisticians, meteorologists and others. The main disadvantages of using such analysis in many countries are the lack of time series data to allow such analysis and the doubtful accuracy of data based on simple observations between weather cycle and agricultural production.

Nonetheless, several studies have been carried out using different techniques to determine the length of the cycle and its effects on certain crops, such as those of Moore and Shaw.(3,4)

10.3.2 Statistical Techniques

Several statistical models have been developed to study weather-crop relationships. In this technique W. Baier has defined weather-crop analysis models as the products of two or more factors, each representing the (simplified) functional relationship between a particular plant response, i.e. yield, and the variations in selected variables at different stages of plant development.(5) J. Mather has classified weather-crop relationships into three groups according to the number and type of exploratory variables (independent variables).(6) These groups are: first, individual primary weather factors, such as temperature and rainfall; secondly, combined primary weather factors; and thirdly, secondary (derived) climatic factors, such as soil temperature and soil moisture.

In the following chapters, an attempt is made to build up a weather-crop model for agriculture in the rainfed area of Iraq using single or combined primary weather variables (see Chapters 12 and 13).

10.4 Data Required for Weather-Crop Studies

It is obvious that two sets of data are required for weather-crop analysis : first, agricultural data, such as the yield per land unit of a particular crop, and secondly, meteorological data, such as rainfall, temperature,etc. Data on each set can be obtained in two ways : the first one is experimental data and the second is time series data.[7]

Experimental data has its advantages and disadvantages. The main advantage of experimental data is that all factors, including weather variables,are under control. Researchers may vary one or two variables at a time and keep the rest constant. Then the influence of such variables on, for example,yield, is measured. The disadvantages are that experimental data is expensive to obtain and requires a large number of technical staff. Moreover, data collected from experimental stations rarely represents the actual weather conditions in the field since only a limited number of secondary variables are introduced. Thus, it can be misleading to use experimental data to measure weather-crop relationship and then simply to extrapolate results to cover a region or country.

Time series data also has advantages and disadvantages. Time series data are always subject to different recording errors, and these will affect the accuracy of explanations of the weather-crop relationship. Also, time series production data are affected by other trends due to changes in production technology,etc, and this may require further analysis before examining weather-crop relationship. This is one reason why earlier chapters concentrated on such non-weather factors. Nonetheless, time series data, where available, are more comprehensive and better represent actual conditions at farm, region and country levels in terms of production and weather variables.

10.5 A General Review of Weather-Crop Studies

It is impossible here to review all type of studies of the analysis of the weather-crop relationship, but it is essential to mention some key types in order to understand the progress achieved in analysing techniques.

10.5.1 Pioneer Studies : One of the earliest attempts to forecast yield from meteorological data was carried out in 1874 by Sir Rawson W. Rawson, the governor of Barbados.(8) His approach was very simple: he compared graphs of the rainfall variable with graphs of yields of sugar cane which was the chief crop of the island. From such comparison, he believed that the yield of sugar cane (hogsheads) could be estimated by multiplying each inch of rainfall in the preceding calendar year by 800.

A series of papers was later published in different countries to explain the influence of weather factors on yields of some crops and there were 2,324 weather-crop studies reported and published between 1900 and 1930 alone.(9,10) In 1907 R.H. Hooker claimed to be the first to use a series of correlations between wheat yield, rainfall and temperature in England.(11) H.L. Moore used the regression technique to forecast cotton yields in the U.S.A. and he claimed that his method was more accurate than other official methods.(12)

In 1924, Fisher used regression techniques to examine the effects of rainfall on the annual yield of wheat at Rothamsted, in particular the rainfall distribution during the growing season and how that affected the final yield.(13) He fitted 5th degree polynomial function to the actual rainfall data of each year and calculated the regression of the actual yield on the coefficient of these polynomials, after eliminating long-term trends. This approach was widely applied later by many people in different countries.

In terms of the practical application of weather-crop relationship studies, in June 1941, the Canadian Agricultural Bureau began to issue for the Prairie Provinces wheat condition figures based on weather factors. At the same time it discontinued the collection of the field observations of crop correspondents. This was the first time an official agency applied weather factors to wheat production forecasts, claiming that on an average of 7 out of every 10 instances, the crop condition figures based on weather factors approximated more closely to the final yield of the crop than did the previously published figures.[14]

10.5.2 Recent Studies : In the last three decades a good deal of progress has been made in studying weather-crop relationship, becoming more sophisticated in terms of mathematical and statistical analysis and/or in the number of variables included or treated in the analysis. With the development of computers, calculation of such sophisticated models becomes easier and faster.

W. Baier says that in spite of this progress weather-crop studies were not seriously considered at the national level by agricultural policy makers until relatively recently.[15] The stock in grain and other foodstuff was very high in most exporting countries during the 1950's and 1960's and agricultural lands were withdrawn from agricultural production partly because of such surpluses. The situation changed during the seventies, the widespread droughts of 1972 being followed by shortfalls in production of foodstuff in most regions. Due to such circumstances attention is now paid to weather-crop studies. Moreover, international organizations such as F.A.O. and W.M.O. have increased their efforts to provide more information on weather fluctuation and its impact on regional and global shortfall of food production. In the following pages, examples from different countries to represent, for example, the objective of the study, the technique involved in the analysis and the importance of the crop under the study are reviewed. In addition, many studies have been reviewed by J. Mather, W.J.Maunder and W.Baier.[16,17,18,19,20]

10.6 Studying The Effect of Weather Factors on Yield and Its Forecasts :

10.6.1 Examples from the U.S.A :

The U.S.A. is one of the leading exporting countries of grain, mainly wheat, corn, maize and soybeans. Until 1972 large stocks of grain were available in spite of various policies to reduce the cultivated land area.

Several techniques have been developed to study the effect of weather on yields of major crops. L. Thompson, for example, published several studies examining the effect of weather on yield of corn, soybeans, sorghum and wheat in the main producing states.[21,22,23,24] His approach is based on multilinear or multi-nonlinear regression techniques and using primary weather variables, e.g. rainfall and temperature during the growing season. He also used linear and non-linear trends to separate the influence of technology from weather. Although this approach can be used to make early forecasts of the yield, Thompson's real objective was to measure the influence of certain weather factors on yield. He found that weather and technology were responsible for 80-90 per cent of the annual yield variation of these crops.

In 1973, L. Thompson and others published a study on the impact of weather on agricultural production of wheat, corn and soybean in the main producing states.[25] The reason for this study was to formulate U.S. agricultural export policy in a manner consistent with the best climatological judgement as to whether or not the favourable weather conditions of the previous years would persist. A multi-regression technique was applied as illustrated in the following formula :

$$Y = A + f_1 \text{ (year)} + f_2 \text{ (weather)} \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where Y is the forecast yield, f (year) is the trend which can be linear or non-linear. In this particular study, it was considered that the trend was linear prior to 1945 and either linear or quadratic from

1945 to 1973. The portion denoted as f (weather) is expressed in the form

$$\sum_{i=1}^{N} B \; (x_i - \bar{x}_i) + \sum_{i=1}^{N} C(x_i - \bar{x}_i)^2 \ldots\ldots\ldots\ldots\ldots \quad (2)$$

where x_i is the monthly state average precipitation or temperature. $\bar{x}_i$ is the long term sample average value of x_i. The coefficients A,B,C are estimated by regression.

Apparently, the conclusions from this study are that weather departure from normal conditions will lower the yield, and secondly, the reliability of grain yield in the previous years was due to an extraordinary sequence of favourable growing seasons which could not be expected to continue.[26]

An alternative way of separating the yield effect of weather factors has been developed in research conducted by the Economic Research Services, U.S.D.A. called the Weather Index.[27] This approach is essentially simple and the general procedure is as follows:-

1. Yield data is collected from agricultural experimental stations where practices have been controlled, where, therefore, year to year variation in yield data will be due primarily to weather.

2. A trend is fitted to the data to describe the yield effect due to changes in factors which were not held constant, such as soil conditions.

3. A weather index from each series was computed as a ratio of the actual yield to the trend yield (computed yield).

4. Weather indices for each crop at each location were weighed together into an index for a particular crop for a particular region or country.[28,29]

Shaw argues that the weather index is more reliable in separating the effect of weather on yield from the effect of technology than regression techniques for the following reasons :[30]

1. In regression techniques the trend might not respresent changes in technology very accurately. Shaw believed that the application of new technology, HYV's for example, follows a logistic function and the level of production is maintained at the same level until a new technology is introduced. Such fluctuation in the production level may be over or under-estimated by fitting a linear trend, for example.

2. In regression techniques, it is assumed that the yield is affected by two broad factors, weather and technology, but it is doubtful whether the two factors are independent. Here, it is assumed that there is an interaction between weather and technology. This interaction might not be solved by the regression techniques.

3. In regression techniques there is a problem of selecting the meteorological variables and geographical aggregation. Clearly, the researcher will select variables which give high explanation (high R^2), but these meteorological variables may not represent the phenological development of the plant, or select them on the basis of agronomic research results. Aggregation may cause errors and require extra work, for example different weighting schemes may be used to construct a yield average and meteorological average.

Shaw believed all these problems would be solved if a weather index is used.

An examination of the first point reveals that the introduction of new technology will not necessarily follow a logistic function, especially in developing countries, since the adoption of a new technology takes a long time to reach its potential level, or near potential level. It is true it will shift the supply curve, but not necessarily in the same pattern which is suggested by Shaw. Fitting a non-linear trend, however, may solve this problem.

As far as the second point is concerned, it seems that measuring the interaction between weather and technology is very difficult to tackle in any model and it requires extra attention.

Selecting meteorological variables which express the relationship between weather and yield is always very difficult. Different weather variables individually or in combined forms may have different effects on yield. The best the researcher can do after sound investigation, is to select the right variables which best express such a relationship for a specific crop at a specific location. Therefore, since the relationship between crop and climate is not yet fully clear, there is no general model which can be applied now. Robertson developed a factorial regression model and claimed it could be applied in any region, but the meteorological variables may still have to be varied.

Regardless of the advantages of the weather index this approach does have a shortcoming. It seems that the data used in this technique, which is based on microclimatic and controlled experiment fields, does not necessarily represent an adequate sample of actual meteorological and agricultural conditions in a region or a country. Even when using weighting techniques to aggregate a weather index to represent a region or a country, this approach is not adequate. Moreover, in most developing countries agricultural experimental stations are very scarce. Shaw noticed this problem and he suggested that plots could be selected from cooperating farmers to represent the bases for weather index calculation.(31) This suggestion is a practical one and can be used in developing countries, especially those which have adopted crop-cutting surveys to estimate the harvest. Nonetheless, extra care should be taken to select the right plot in the sample.

Another technique to estimate a weather index, by J.P. Doll, is to estimate yield response as a function of meteorological data and trend. Doll believed his model gave a more accurate weather index than that of Shaw and Stalling.[32] In his conclusion, Doll says that calculating a weather index based on one variable cannot be taken as a final word.

10.6.2 Examples from Canada : Canada is particularly interested in the world wheat production and market situation since it has long been one of the larger producers in the world. Most of the Canadian wheat crop is grown in the three Prairie provinces and since this area is more uniformly delimited in extent than other major wheat producing areas in the world, the balancing of drought or disease losses in one part of the area by good conditions in another part is less likely. Consequently, fluctuations in national wheat production are often greater in Canada than in other major wheat producing countries.[33] Analysing weather-crop relationships to forecast or to measure the impact of weather factors on wheat is obviously very important at national and international levels.

G.W. Robertson developed a Factorial Yield-Weather Model (FYWM) to forecast wheat yield at Swift Current in the Saskatchewan province of Canada.[34,35] This FYWM, Robertson says, contains some desirable characteristics which others neglect. These characteristics are summarized as :-

1. The model should include basic weather elements which directly affect the growth and development of the crop and which are readily available from meteorological networks or can readily be estimated from available data. Elements considered basic for this purpose are daily maximum and minimum air temperature, global radiation, and soil moisture (or rainfall in semi-arid regions).

2. These basic elements should be used in realistic combinations in a mathematical formula which will permit the determination of characteristic crop response functions for each element.

3. Provision must be made for including antecedent crop conditions.

4. The model should permit the evaluation of the current crop condition in terms of potential yield at any time during the growing season.

5. The model should permit the use of forecast weather elements, when available, or of climatological probabilities should it be desirable to determine the probable potential yield distribution under various future conditions.[36]

Although Robertson mentioned the possibilities of using daily weather variables, he used monthly data in his application of this model at Swift Current.

Generally speaking, the FYWM involved the summation of the products of several quadratic or linear functions of the various weather elements mentioned before.[37]

At Swift Current, the improvement in the accuracy of the estimates, as the season progresses, is indicated by the value of the coefficient of determination (R^2) for the estimated yield against observed yield which increased from 27 per cent at the end of April to 73 per cent at the end of August, and the value of the standard error of estimates decreased from 524 kg/hectare at the end of April to 355 kg/hectare at the end of August.[38] Increasing the accuracy of forecasts as the harvest approaches is also considered important by Moore, Baier and Williams.[39,40] G.W. Robertson applied his model to forecast fresh fruit bunch yield of oil palm trees in Malaysia.[41] A similar technique was developed by Baier.[42,43]

10.6.3 Example from India : Several attempts have been made to study the effects of weather variables on agricultural crops, such as rice, wheat and maize.[44,45,46] In the case of rice, for example, it has been realized that an above average weekly total rainfall during the nursery period is beneficial (the period between emergence and transplanting). During the vegetative period heavy monsoon rain has an adverse effect on the final yield. The ripening phase is the phase which is most susceptible to excess rainfall.[47]

10.6.4 Examples from other Countries : Forecasting yields by using meteorological data has spread to many countries.

In Iran, for example, J. Lomas conducted a special study to assess the probability of predicting wheat yield in Iran from rainfall data in such a manner that it would provide an objective assessment of the wheat potential of the main wheat growing area of Iran. He found that from a linear simple regression model using verified 1972 data from 18 experimental sites that 52 per cent of the wheat yield variation could be explained by rainfall.[48]

Hashemi used Iranian regional wheat production figures, including both irrigated and non-irrigated yield data, of the Ministry of Agriculture for a five year period to determine the response of total wheat output to changes in September - June precipitation. Greatest yield response, roughly 10% per 10 mm. changes in precipitation, was found in regions where the total September - June precipitation was only 50 mm. Most of the wheat in this area is produced with the aid of supplementary irrigation. Regions having more than 400 mm. respond negatively to an increase in precipitation.[49]

Hashemi, however, managed to make a forecast of wheat yield at the national level by using November - April precipitation as in the following equation -

$$Y = 375 P - 16.5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$
$$(r = 0.78)$$

In Egypt, A.K.A.A.H. Ali investigated the effect of weather/climate on five main agricultural products : cotton, maize, wheat, rice and sugar cane.(50) He applied two techniques. The first was a correlation analysis between the yield of individual crops and five weather variables : maximum and minimum temperatures, relative humidity, wind speed and sunshine. He used average weather factors during the growing season in the first correlation series and then correlated monthly weather variables during the growing season in the second series. He found from this analysis that the monthly weather variables in general are more significantly correlated with yield than average weather factors during the growing season.

In the second approach he used the Fisher equation mentioned above to study the effect of minimum and maximum temperature on yields of products mentioned earlier.

One of the many studies carried out in Israel was that by J. Lomas to study the economic significance of dry farming in the arid region.(51) He used simple and multi regression, principle component analysis and the Fisher equation to study the relationship between wheat yield and rainfall. All these methods showed good results. He concluded that a 20 per cent profit margin could probably be obtained in seven of every ten years only in an area where the mean annual rainfall is at least 300 mm. Where rainfall is below 300 mm. additional irrigation is essential, for in an area of 240 mm. 20 per cent profit margins can only be obtained 3-4 times in every 10 years.

10.7 Using Weather-Crop Relationship in Agricultural Production Functions

As noted earlier the weather-crop relationship can be used in production or supply functions (see page 383). The argument among economists, however, is whether to use primary weather variables or a weather index. J.L Stallings argues that weather index is a useful presentation of weather elements in a supply function and it has been used in several occasions, as we will see later.[52,53] Other economists, however, prefer to use primary weather variables.

Z. Grilliches took the weather index which was calculated by J.L. Stallings and calculated an aggregate supply elasticity by using a simple lag distributed model.[54] Relative price, technology and other economic variables were used in the model, in addition to the weather index earlier mentioned. He found that the weather index proves to be a very useful tool of analysis, accounting for a substantial fraction of the explained variance, and he went on to say, "On the whole, the results seem to indicate that a ten per cent change in the 'Stallings' weather indices implies a change of about 4 per cent in both the total farm output and all crops output indices."[55]

B. Oury says : "The model builder hopes to construct a system that offers a structure approximating reality to a degree sufficient for the practical purpose of investigation. Such a structure is described through a set of relations regarding environmental factors, human behaviour, as well as technological and institutional factors, and through the joint probability distribution of non-observable random disturbances and errors of measurement. Its validity is subject to changes and depends upon the degree of permanence of economic laws, as well as that of the state of technology".[56]

Bearing in mind this view, Oury attempted to build an econometric model to estimate yield and acreage separately of wheat in France, and the total production as results of these two models. In a third model B. Oury estimated the total production directly.

He selected weather variables, economic variables and other variables which represent technology or trends. His analysis was based on two premises: first, the study of the influence of weather variables on yield, acreage and total production and secondly, the selection of significant variables to be used in estimating yield, acreage and total production.

Considering weather variables, he tested a large number of individual weather variables such as number of rainy days, rainfall and the T. De Martonne aridity index which is -

$$I = \frac{P}{T + 10} \qquad \text{..................} \qquad (4)$$

where:

I = De Martonne aridity index

P = Precipitation cm.

T = Temperature °C

Oury maintained that the aridity index has many advantages.(57)

As for economic variables, he used wheat price ratio to other crops, such as barley and maize, fertilizer consumption, wheat price, etc. In all he selected fifty independent variables to be used in different models.(58)

For the yield model Oury managed to explain 91 per cent of the average yield of all wheat with a standard error of estimate smaller than 150 kilograms per hectare, or 7.5 per cent of the average yield of the period under the study. Also, he said it is possible to use the model as soon as April weather conditions are known, to get the first guess-estimate of the yield of wheat and then to get progressively closer and closer to the actual value as soon as precipitation and temperature data become available for May, June and July. High explanation and low standard of error were obtained in the acreage model and the direct production models.

A. Coffing used the T. De Martonne aridity index to forecast (pre-harvest) wheat production in Turkey.(59) In foreign trade, Turkey depends to a large extent on wheat export, and variation in weather condition, especially rainfall, causes an annual fluctuation in wheat output. So, it is obvious that pre-harvest estimates provide very valuable information.

An aridity index was used to compute the effect of weather. Use of the index has an advantage over the use of a precipitation variable alone in the production function because the index includes the temperature, through its effect on evaporation, and on the availability of soil moisture for plant growth.

Coffing used the same approach as Oury by estimating production directly and indirectly. Indirectly by forecasting the yield of wheat and area under production in separate models. Then he estimated production by multiplying the estimated yield by the estimated area. The standard error estimation was 9 per cent for the yield and total production models and 4 per cent for the area model.

Although some economists have used different forms of weather indices, many economists have used primary weather variables in their studies. J.W.B. Guise, for example, used primary weather variables in a Cobb-Douglas function to study factors affecting the annual aggregate average wheat yield in New Zealand. (60) Over 98.6 per cent of the variance of the dependent variables in the sample was accounted for by the regression relationship involving seven weather and four non-weather variables, only one of which related to technological changes. Although Guise says that weather variables used in this model are over-simplified, it does appear to provide a reasonable quantitive estimate of the influence of weather on wheat yields. Also, he added that a simple function of specific weather elements, such as those used here, can never capture all the nuances of weather, but crop yield response often appears to be closely associated with gross changes in certain elements of weather.

Since the impact of certain weather variables on agricultural production and agricultural productivity of a single crop has been successfully measured, these relations might be used to evaluate farmers' profits or losses in a single season which are caused by changes in the weather conditions. Several studies have been carried out to make such assessments.[61,62,63] For example, W.J. Maunder studied the fluctuation in agricultural income in New Zealand, and he concluded that significant changes in agricultural income do take place as a result of weather changes. The effect of such variations may affect the agricultural exports upon which the country depends.[64]

10.8 Conclusion

This chapter has dealt with a general review of weather-crop relationships and emphasised their importance to various fields, such as economic, irrigation, and agronomy studies.

Generally speaking, weather-crop relationship studies have had two main approaches : weather cycles and statistical techniques. Although many studies have been carried out to relate fluctuation of agricultural production to certain weather cycles, the results, so far, are not very satisfactory for forecasting yield.

Statistical techniques are the most commonly used to forecast yield from meteorological data. In these techniques yield is expressed as a dependent variable and weather variables and trend as independent variables. Weather variables have taken either single or combined primary variables, or secondary variables. Many models have been developed using regression or factorial analysis, but the most common technique is multi-regression analysis - the Fisher equation and FYWM are examples of such techniques.

A high proportion of variation in the annual yield of particular crops has been explained by these models, and generally speaking, the accuracy of the forecasts increases progressively as the final harvest approaches. This does not mean that the relation between plants and weather is not important at the early stage of the plant growth, but it means that in the early stage of plant growth no direct way has been found of measuring the correlation between yield and weather variables under field conditions.

Another attempt was made in the U.S.A. to measure the impact of weather on crops by calculating Weather Index from experimental data. This method has its shortcomings because the type of data used was inadequate.

Experience shows that the weather-crop relationship is very useful in improving the accuracy of production function assessment or in evaluating farmers incomes. We consider the implication of these relationships in Iraq in the following three chapters.

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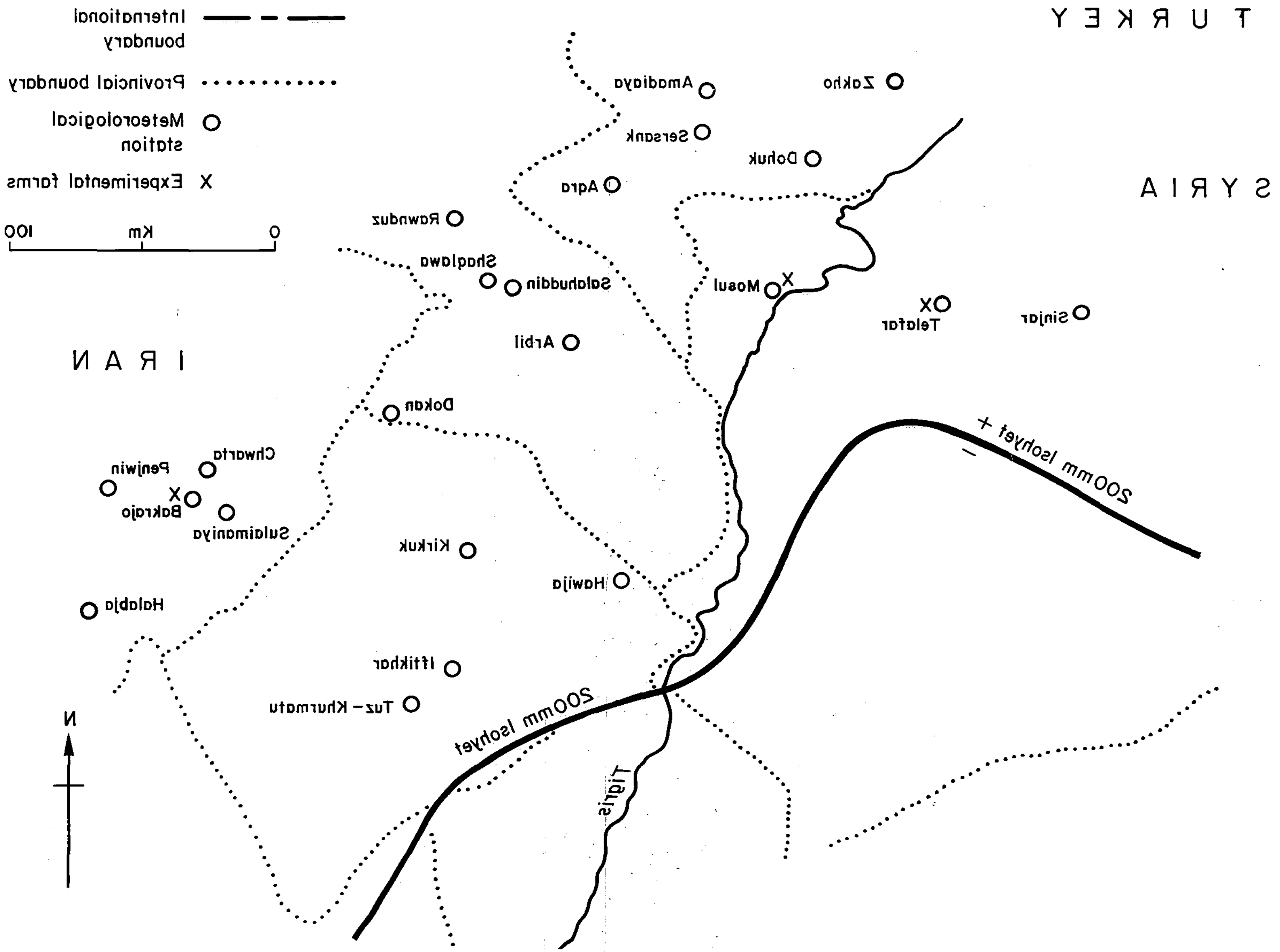
Fig. II·15 THE NORTHERN PROVINCES OF IRAQ – RELIEF AND LOCATION



CHAPTER ELEVEN

AGROCLIMATOLOGICAL CONDITIONS

11.1 Introduction

It is clear from Chapter 10 that the implications of the weather-crop relationship is significantly important in many aspects of agricultural planning and development and, therefore, several models have been developed to express such relations.

Analysing weather-crop relationship, as noted earlier, requires two sets of data: agricultural and meteorological. The purpose of this chapter is to examine, in detail, the available agricultural and meteorological data which can be used for the investigation of weather-crop relationship in Iraq. Agricultural data, such as total production and total cultivated area, are obtained from the annual statistical abstract for the period between 1949/50 and 1968/69 and directly from the Ministry of Agricultural and Agrarian Reform for the period between 1969/70 and 1975/76. The choice in each case is determined by the need to ensure that agricultural data series are drawn from the most consistent and smallest number of sources. Meteorological data are obtained directly from the Meteorological Office. Other data obtained from other sources when needed are referenced.

11.2 Area Under Study

Although weather affects agricultural production throughout the country, the rainfed area in the Northern region of Iraq has been chosen for such investigation for the following reasons:-

(1) In the Central and Southern regions agriculture depends on irrigation as supplementary to rainfall in winter and as a necessity in summer. Irrigation as a modifier of the impact of climate and weather on agriculture therefore introduces human action as another variable

to the weather-crop relationship.

(2) The addition of irrigation as another factor to the equation also requires the consideration of other physical data at the micro level (farm level) on crop conditions, and such analysis is beyond the objective of this study. Irrigation also introduces further variables in soil characteristics. Since soils are relatively free from irrigation induced salinisation and water logging in the rainfed area, this helps to eliminate the effect of these factors on yield (see page 349).

(3) In this region a crop-fallow annual succession is uniformly adopted in grain cultivation and this strengthens uniformity against which we can study the weather-crop relationship.

11.3 Crops Under Study

Two crops will be considered in this sample investigation of the impact of certain weather factors on agricultural productivity in Iraq. These crops are winter grown wheat and barley and are chosen for the following reasons:-

(1) Both are winter crops which depend upon winter conditions in general and rainfall in particular during the growing season.

(2) These two crops are extremely important regionally in terms of area under cultivation and of production as we will see later.

(3) These crops are not only important to this particular region, but are also important from the national economic point of view (see page 70). Since government efforts are directed towards self-sufficiency in wheat and barley as staple foodstuffs, this study has immediate and direct applied value.

11.4 The Distribution of Wheat and Barley Production

We noted in Chapter 4 that the rainfed region is dominated in winter by cereal production, mainly wheat and barley. Table 11.1 shows that two-thirds of the national area under wheat production is in the rainfed Northern region. This area produced 60 per cent of the total national production of wheat - Table 11.2. Barley lies in second place with the Northern rainfed area possessing nearly 38 per cent of the national area under barley and producing about 35 per cent of the national total (see Tables 11.1 and 11.2). Clearly, any weather effect on such crops can have significant positive or negative consequences for the whole country.

Within the Northern region, Tables 11.3 and 11.4 reveal that Nineveh is the leading province for production of and area under wheat and barley, followed by Kirkuk, Arbil and Sulaimaniya. Nineveh and Kirkuk Provinces together have three-quarters of the area and total production of wheat and barley.

11.5 Agricultural Data

The three main components are : total cultivated area, total production and yield.

11.5.1 The Cultivated Area : The cultivated area under wheat fluctuated irregularly during the period under the study (1949/50 - 1975/76). The coefficient of variation during this period is 30.4 per cent for the whole region (see Table 11.5), very high compared with the 15 per cent variation coefficient of area under wheat production in the rainfed area of Syria.[1] The largest area under wheat production was reported in 1971/72, at a total of 7,124 thousand donums; the lowest recorded was 1,173 thousand donums in 1949/50 (see Table 11.5 and Appendix H, Table H.1 for details). Regarding the variation of area under wheat production, Table 11.5 shows the mean, minimum, maximum,

Table 11.1 The Distribution of Area Under Wheat and Barley by Regions in Iraq*

Region / Crops	North %	Centre %	South %	Total %
Wheat	66.38	17.36	16.26	100
Barley	37.75	29.29	32.96	100

* Average of 27 years

Source : calculated from Appendix H, Tables H.1 and H.3

Table 11.2 The Distribution of Wheat and Barley Production by Regions in Iraq*

Region / Crops	North %	Centre %	South %	Total %
Wheat	59.30	19.91	20.79	100
Barley	35.11	30.28	34.61	100

* Average of 27 years

Source : calculated from Appendix H, Tables H.2 and H.4.

Table 11.3 The Provincial Distribution of the Area Under Wheat and Barley in the Northern Region

Crops / Province	Wheat	Barley
Nineveh	57.90	50.46
Arbil	16.80	16.63
Sulaimaniya	5.30	7.32
Kirkuk	20.00	25.59
Total	100	100

* Average of 27 years

Source : calculated from Appendix H, Tables H1 and H3.

Table 11.4 The Provincial Distribution of the Production of Wheat and Barley in the Northern Region*

Crops / Province	Wheat	Barley
Nineveh	57.70	51.11
Arbil	15.10	14.29
Sulaimaniya	7.50	7.92
Kirkuk	19.70	26.68
Total	100	100

* Average of 27 years

Source : calculated from Appendix H, Tables H2, H4.

Table 11.5 The Mean, Maximum, Minimum, Standard Deviation and Coefficient of Variation of Area Under Wheat and Barley Production in Northern Iraq*

(000 Donums)

Province \ Crops	Wheat					Barley				
	Mean	Maximum	Minimum	S.D.	Coeff. variation	Mean	Maximum	Minimum	S.D.	Coeff. variation
Nineveh	2,524.30	3,709.0	967.0	898.71	35.6	811.37	1,272.0	357.0	205.54	25.33
Arbil	732.52	1,169.0	222.0	190.98	26.1	267.37	423.0	129.0	88.62	33.2
Sulaimaniya	230.19	818.0	62.0	216.63	94.1	117.74	333.0	44.0	64.93	55.2
Kirkuk	870.56	1,483.0	428.0	216.61	24.9	411.48	579.0	205.0	99.89	24.3
Northern Region	4,347.9	7124.0	1,732.0	1,320.8	30.4	1,608.0	2,140.0	1,181.0	286.04	17.8

* Average of 27 years.

Source : Calculated from Appendix H, Tables H.1 and H.3.

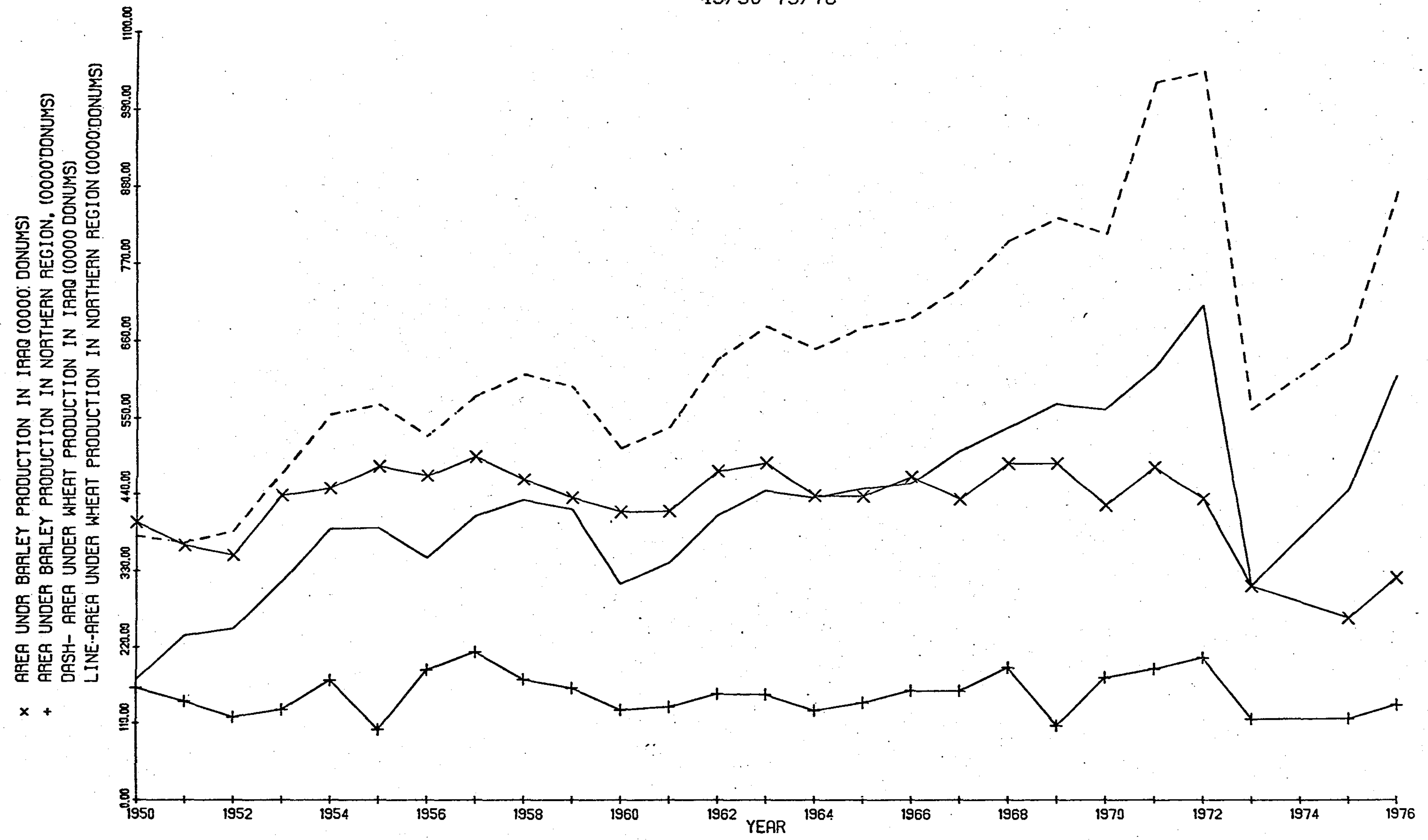
standard deviation and the coefficient of variation for the whole region, as well as for each province. It is clear from this that the lowest variation in area under wheat occurred in Kirkuk, followed by Arbil, Nineveh and Sulaimaniya respectively.

The area under barley production fluctuated less than the area under wheat as can be seen in Table 11.5. The coefficient of variation is 18.7 per cent for the Northern Region as a whole. The maximum area under barley production was 2,140 thousand donums in 1956/57 and the minimum area was 1,181 thousand donums in 1972/73. As far as the variation of area under barley production is concerned, Table 11.5 shows the mean, maximum, minimum standard deviation and the coefficient of variation for provinces, as well as for the whole region. It is clear from this table that the lowest variation of area under barley was in Kirkuk and Nineveh. Table 11.5 also shows that Nineveh and Kirkuk are the major producing provinces of wheat and barley. Fig.11.1 shows the production area of wheat and barley in Iraq and in the rainfed areas.

11.5.2 Production : The second component of agricultural data is the total production of a particular crop (wheat and barley in the case of this study). Table 11.6 shows the mean, maximum, minimum, standard deviation and the coefficient of variation by province, as well as for the whole region. We see that wheat production also fluctuated during this period of the study (see Appendix H, Table H.2 for details). The coefficient of variation of wheat production is 64.3 per cent for the whole region. In a similar study carried out in the rainfed area of Syria and Jordan, Al-Shirbini has found the coefficient of variation of wheat production are 40 and 52 respectively, both lower than in Iraq.(2)

Moreover, comparing the coefficient of variation between wheat production and area under wheat production reveals that wheat production fluctuated almost twice as much as the area under wheat production.

FIG. 11.1 AREA UNDER WHEAT & BARLEY PRODUCTION IN IRAQ AND IN NORTHERN REGION, 1949/50-75/76



This means that wheat production is not only affected by areal variation, but also by other factors which could be environmental, mainly weather, socio-economic and technical factors. In other words, production is also affected by fluctuation of the yield per land unit.

Regarding fluctuation in wheat production in each province, Table 11.6 shows that Arbil had the lowest production fluctuation during this period. Nineveh and Kirkuk share the second place, a similarity which is not surprising given the similarity of the weather conditions in these two provinces, as we will see later. Sulaimaniya had an exceptionally higher production fluctuation than other provinces, partly attributable to the high fluctuation of sown area and partly to other factors (Table 11.5).

Barley production, on the other hand, shows less fluctuation than does wheat. Table 11.6 shows the mean, maximum, minimum, standard deviation, and the coefficient of variation of barley production for the whole region as well as for each province. The maximum production was 680 thousand tons which occurred in 1953/54 and the minimum production was 138 thousand tons in 1974/75 (see Appendix H, Table H.4 for details). The coefficient of variation of barley production is 50.7 per cent which is less than the coefficient of variation of wheat production, for reasons established later in this thesis. Table 11.6 shows that Arbil had the lowest provincial barley production fluctuation, followed by Nineveh, Kirkuk and Sulaimaniya respectively. Sulaimaniya, however, shows high fluctuation in barley production. Fig.11.2 shows wheat and barley production in Iraq and in the rainfed area.

11.5.3 The yield : The yield of a particular crop is a function of two factors : the total production and the cultivated or harvested area. These two components, especially production, are subject, as noted earlier, to the three major influences; socio-economic, technical and environmental (See Fig. 1.1).

FIG. 11.2 WHEAT & BARLEY PRODUCTION IN IRAQ & NORTHERN REGION, 1949/50-1975/76

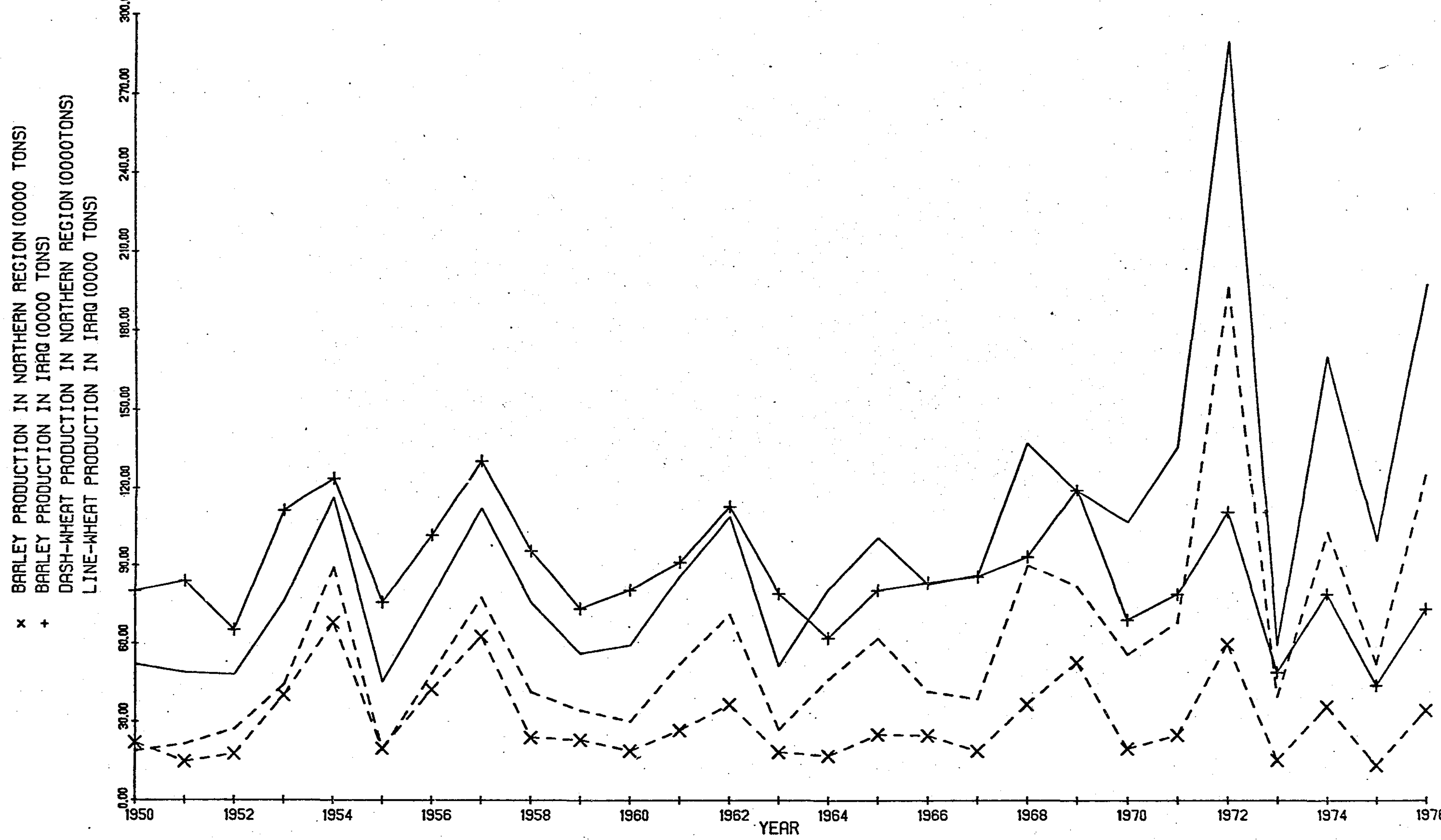


Table 11.6 The Mean, Maximum, Minimum, Standard Deviation and the Coefficient of Variation of Wheat and Barley Production in Northern Iraq

(000Tons)

Crop / Province	Wheat					Barley				
	Mean	Maximum	Minimum	S.D.	Coeff-variation	Mean	Maximum	Minimum	S.D.	Coeff-variation
Nineveh	342.67	1,125.0	52.00	232.07	67.7	154.96	395.00	36.00	91.257	58.9
Arbil	89.63	201.0	19.00	43.263	47.2	43.33	81.00	16.00	20.914	48.3
Sulaimaniya	44.44	214.0	2.00	51.599	116.1	24.00	117.00	2.00	22.573	94.1
Kirkuk	117.26	416.0	45.00	79.688	68.0	80.89	250.00	24.00	52.651	65.1
Northern Region	593.8	1,956.0	187.0	381.93	64.3	303.41	680.00	138.00	153.82	50.7

* Average of 27 years.

Source : Calculated from Appendix H, Tables H.2 and H.4.

Earlier examination of the impact of the socio-economic and technical factors, has shown that these factors have had limited effects on improving yield per unit in the rainfed area in particular. It may be, however, assumed that yield is subject to areal variability and weather conditions.

Since area is an essential element in the measurement of yield, it is necessary to investigate two specific points : first, the relation between the area under cultivation and total production and secondly, the trend, or the increase or decrease in cultivated/harvested area which is associated with total production during the period under study.

Hypothetically, if the correlation between total production and area is negative, one may expect that production is increasing whilst area is declining. On the other hand, if the correlation between production and cultivated land is highly positive, one may expect that an increase in cultivated area is mainly responsible for increasing production.

As far as Northern Iraq is concerned, Table 11.7 shows the correlation between area under wheat production and total production is 0.74, significant at 1 percent level. This means that an increase in area under production was the most important single factor in increasing the total wheat production. This situation is similar to the case of East Jordan where Al-Sherbini has found that the correlation between total wheat production and harvested area is 0.809 and for Irbid, Amman and Karak are .582, .746, .769 respectively. (3) The highest correlation between wheat production and area under production is .965 in Sulaimaniya. Although there is a high correlation between wheat production and area under production in Sulaimaniya, there is also a high coefficient of variation in wheat production and area under production (see Tables 11.5 and 11.6). The correlation between wheat production and area under production are .74, .67, .65 for Kirkuk, Nineveh and Arbil respectively.

In the case of barley, the correlation between area under production and total production is .62 for the Northern region as a whole, significant at 1 per cent level (see Table 11.7). This correlation is lower than the correlation between wheat production and area under production for the same region. This is probably due to the fact that barley production and area under production fluctuated more randomly than the case of wheat (and see later). The correlation between barley production and area under cultivation for each province are .78, .62, .61 and .54 for Sulaimaniya, Kirkuk, Nineveh and Arbil respectively. These correlation coefficients are also lower than the correlation between wheat production and area under production for the same provinces. Fig. 11.3 shows total production, area under production and the yield of wheat and barley in the rainfed area.

Examining the impact of area on production and consequently on yield requires looking at the trend (increases or decreases) in area cultivated during the period under study. A series of regression analyses has been carried out separately for area and production of wheat and barley as dependent variables and years, taking time as an independent variable starting 1 for 1949/50 and 27 for 1975/76.

For the whole region, Table 11.8 shows that there is a significant increase in both area and total production of wheat. Therefore, the area under wheat production increased at a faster rate than the total production (see Fig.11.4).

Since an increase in area was mainly responsible for increasing total production then yields per land unit were not significantly increasing. The implications of these trends will be discussed later.

FIG. 11.3 PRODUCTION, AREA UNDER PROD. & YIELDS OF WHEAT & BARLEY IN THE NORTHERN REGION OF IRAQ ,1949/50-75/76

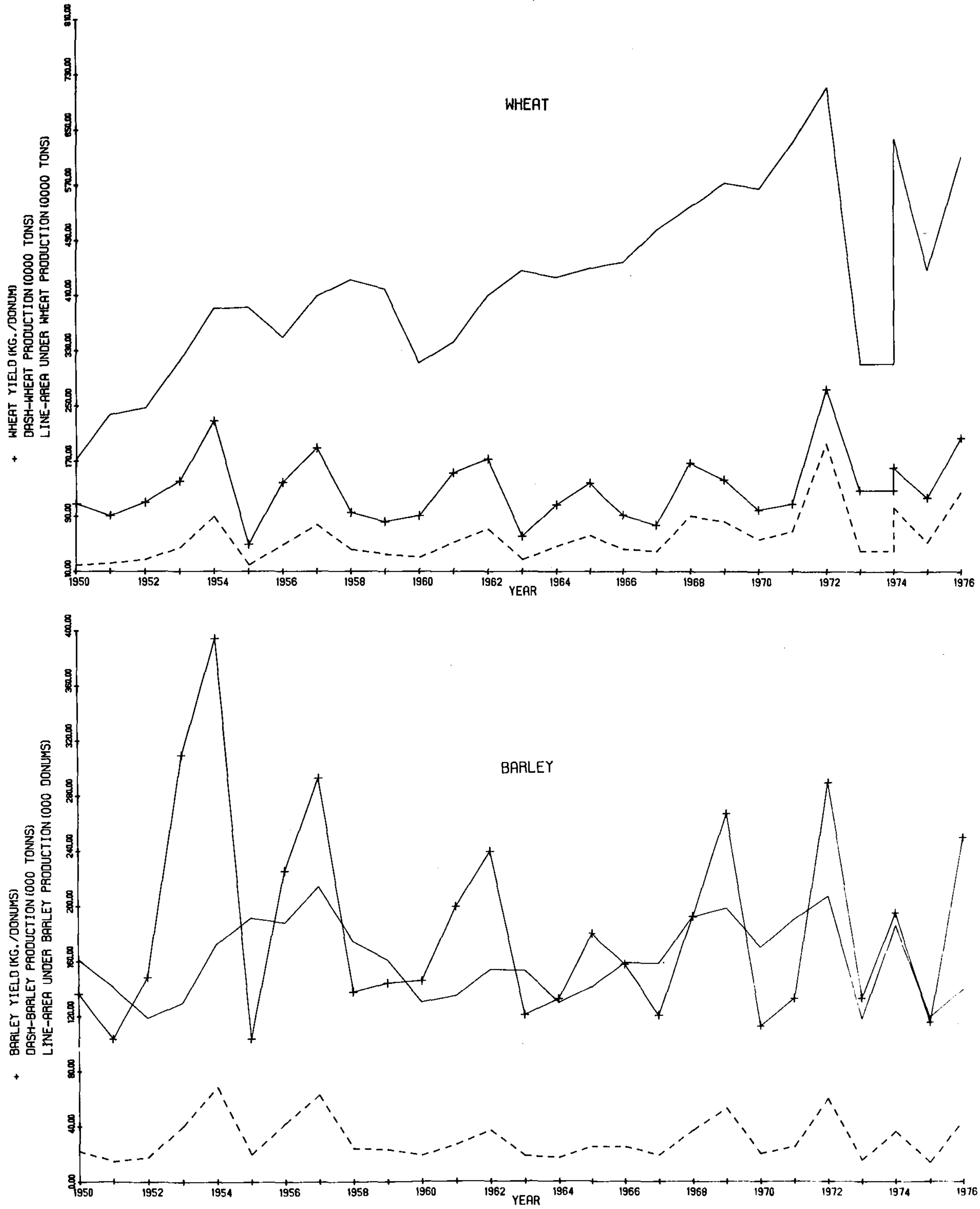
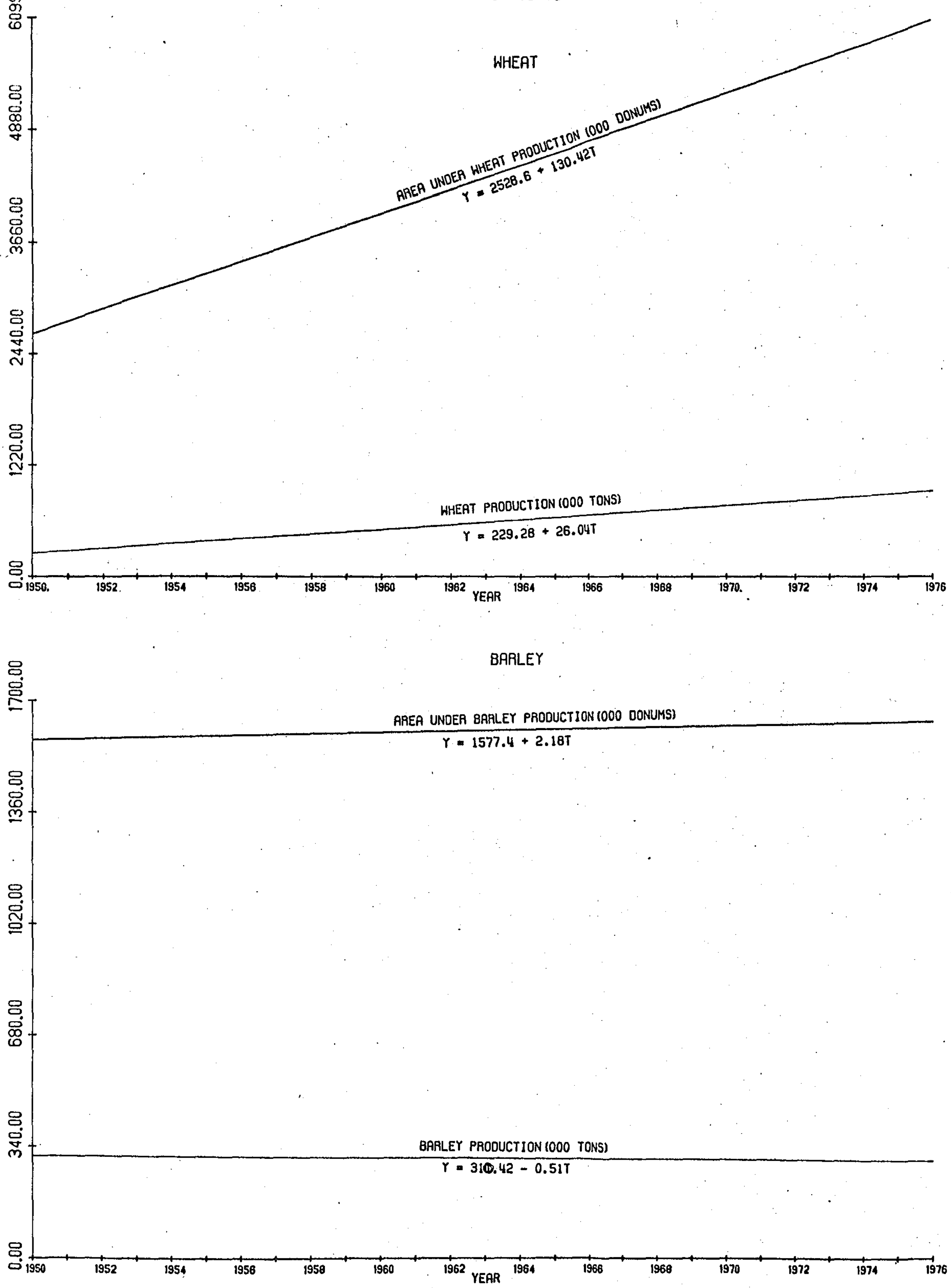


FIG. 11.4 TRENDS IN WHEAT & BARLEY PRODUCTION IN THE RAINFED AREA OF IRAQ.*
1949/50-75/76



* WHERE T=1-27

Table 11.7 The Correlation Between Production and Area under Production*

Province \ Crops	Wheat	Barley
Nineveh	.6745	.6139
Arbil	.6506	.5397
Sulaimaniya	.9656	.7780
Kirkuk	.7410	.6190
Northern Region	.7444	.6186

* Significant at 1% leval

Source : Calculated from Appendix H, Tables H1, H2, H3 and H4.

Table 11.8 Regression Analysis of Wheat Production and Area Under Production on Time*

Province	Functions	r	r^2	S.E.
Wheat Production				
Nineveh	125.44 + 15.22 T (3.13)	.53	.28	200.59
Arbil	50.775+ 2.76 T (2.96)	.51	.26	37.97
Sulaimaniya	-13.316+ 4.13 T (4.11)	.64	.40	40.67
Kirkuk	67.22 + 3.57 T (1.91)	.36	.13	75.94
Northern Region	229.28 + 26.04 T (3.22)	.54	.29	327.56
Area				
Nineveh	1423.5 + 78.631 T (4.83)	.69	.48	659.50
Arbil	452.17+ 20.023 T (7.50)	.83	.69	107.98
Sulaimaniya	-388.738+ 19.21 T (4.95)	.70	.50	156.95
Kirkuk	691.75 + 12.56 T (2.60)	.46	.21	196.12
Northern Region	2528.6 + 130.42 T (6.38)	.79	.62	827.83

* Value in brackets is the t-value for significance tests.

Source : Calculated from Appendix H, Tables H.1 and H.3.

Table 11.9 Regression Analysis of Barley Production and Area Under Production on Time*

Province	Functions	r	r^2	S.E
Barley Production				
Nineveh	143.03 + 0.85 T (0.37)	.007	.005	92.808
Arbil	40.43 + 0.21 T (0.4)	.08	.006	21.3
Sulaimaniya	28.59 + 0.33 T (0.58)	.12	.01	22.87
Kirkuk	98.35 - 1.25 T (0.96)	.19	.04	52.74
Northern Region	310.42 - 0.52 T (0.13)	.03	0.00	156.83
Area				
Nineveh	782.55 + 2.06 T (0.40)	.08	0.006	208.95
Arbil	199.62 + 4.84 T (2.41)	.43	.19	81.45
Sulaimaniya	117.19 + 0.04 T (0.02)	.005	0.00	66.22
Kirkuk	480.27 - 4.99 T (2.16)	.40	.16	93.51
Northern Region	1577.4 + 2.18 T (0.30)	.06	0.004	291.17

* Value in brackets is the t-value for significance tests

Source : Calculated from Appendix H, Tables H.2 and H.4.

For the individual provinces, it is clear from Table 11.8 that area everywhere increased at a faster rate than total production.

Table 11.9 shows the results of the similar regression analysis for barley. It is clear that barley production did not increase during the period under study for the whole region and also that none of the regression functions are significant. Area under production shows no significant increase except in Arbil province. Nonetheless, the rate of growth is very small compared to the rate of growth of the area under wheat production. Kirkuk province, on the other hand, shows a decline in the area under barley production, which could be related to economic factors.

It might be concluded from the foregoing discussion that the rate of growth of wheat production was lower than the rate of area under wheat production. Neither barley production nor area under production show any significant increase.

Since the rate of areal growth was faster than the rate of production growth, it might be expected that there was no significant change in the yield of wheat and barley for 1949/50-1975/76. Appendix H, Tables H.5 and H.6 show the yield of wheat and barley respectively for the period mentioned. It is clear that the yield of these two crops fluctuated as a result of area fluctuation and other factors, mainly weather. Nonetheless, another set of regression analysis has been carried out to test any significant improvement in the yield of these two crops. In this case the yields of wheat and barley were taken as dependent variables and time as an independent variable. Generally speaking, the results of this analysis show there were no significant changes in the yield of wheat or barley (see Table 11.10). The rate of growth of barley yield is actually negative which suggests the yield per unit is declining, but this is statistically an insignificant change because the test of significance of the regression analysis is very low.

Table 11.10 Regression Analysis of Yield on Time in the Rainfed Area in the North of Iraq

Provinces	Function	r	r^2	S.E.
Wheat				
Nineveh	106.47 + 1.72 T (1.20)	.23	.05	58.10
Arbil	116.87 + 0.27 T (1.10)	.05	.002	44.24
Sulaimaniya	146.41 + 1.50 T (1.41)	.21	.04	57.00
Kirkuk	107.23 + 1.58 T (1.43)	.22	.05	57.80
Northern Region	108.91 + 1.55 T (1.23)	.24	.06	51.21
Barley				
Nineveh	188.96 - 0.14 T (0.63)	.01	0.00	88.10
Arbil	195.93 - 2.24 T (1.56)	.30	.09	58.02
Sulaimaniya	201.68 - 1.02 T (0.51)	.1	.01	81.34
Kirkuk	201.31 - 0.94 T (0.40)	.08	.006	95.92
Northern Region	194.98 - 0.75 T (0.40)	.08	.006	76.52

Value in brackets is the t-value for significance tests.

Source : Calculated from Appendix H, Table H5 and H6.

Table 11.11 The Mean, Minimum, Maximum, Standard Deviation, and the Coefficient of Variation of Wheat and Barley Yields by Province in the Rainfed Area of Northern Iraq*

(Kg./Donum)

Crops / Province	Wheat					Barley				
	Mean	Minimum	Maximum	S.D.	Coeff-variation	Mean	Minimum	Maximum	S.D.	Coeff-variation
Nineveh	131.63	31.60	308.0	59.466	45.18	187.04	58.100	358.60	86.345	46.16
Arbil	120.66	31.40	200.00	43.405	35.97	164.62	42.900	278.50	59.608	36.21
Sulaimaniya	167.32	18.50	333.00	57.106	34.13	187.44	21.50	487.50	80.162	42.77
Kirkuk	129.31	49.600	280.50	57.967	44.83	188.14	83.100	484.50	94.265	50.10
Northern Region	130.62	49.20	274.60	51.71	39.60	184.50	103.70	394.20	75.27	40.80

* Average of 27 years

Source : Calculated from Appendix H, Tables H5 and H6.

These general results are not surprising in the context of earlier sections of this study. For purposes of our analysis it means that we can ignore any yield trends of the kind that might have been expected from the influence of factors other than weather and climate. A similar situation has also been observed in Jordan and Syria.(4) Table 11.11 shows the mean, minimum, maximum, standard deviation and the coefficient of variation of wheat and barley yield. It is clear from this table that the coefficient of variation of the yield of barley is relatively higher than that of wheat. Since there was no significant improvement in both yields, it could be assumed that these variations are related to weather variations, areal fluctuations and random variation.

11.6 Meteorological Data

This is the second set of data which is required for weather-crop relationship studies. Here, it might be useful first to give a general picture of the Iraqi climate and later more detail for the rainfed area.

Iraq lies approximately between the latitudes of 30^{o}N to 37^{o}N and longitude of 38^{o}E to 48^{o}E and it is, therefore, located in the southern portion of the temperate zone of the northern hemisphere.(5) Winter is cold and wet compared with other seasons and lasts from December to February. Spring, March to April, is characterized by a rapid increase in temperature and rain which comes in the form of heavy showers accompanied by thunder storms. Summer is hot and rainless lasting from May to September. Autumn lasts from October to November and temperatures drop and cloudiness increases during this season.

Meteorological observations were first made in 1888, and in 1936 the Meteorological Department of the Directorate General of Civil Aviation was established.(6) Although the number of meteorological stations has increased, the discontinuity of recording meteorological observations is still a major problem.[7,8] In addition, lack of adequate and reliable data is still a matter of concern.[9]

In 1968, the first agroclimatological observatory was opened at Fadhaliya, about 20 km. north-east of Baghdad.[10] It was difficult, however, for the observatory to cover all relative factors to provide average data. Moreover, a single agroclimatological observatory is inadequate for serious studies and the location of the centre makes its observations largely irrelevant to the rainfed zone.

11.7 Precipitation

The average annual rainfall for the whole country has been estimated to be 260 mm.[11,12] In the north the annual rainfall is much higher than the average, while the desert receives much less rainfall. Rainfall is also influenced by the topography of the country. The mountain region in the north receives higher annual rainfall, while the lowlands of the Mesopotamian plains are characterized by low amounts of rainfall.[13,14] Except, however, for the high mountain region in the north and north-east during the coldest part of the winter season, precipitation in Iraq is always in the form of rain.[15] Table 11.12 shows the mean monthly, seasonal and annual rainfall for a number of stations spread all over the country. It is clear from this table that stations in the north and north-east, such as Salahuddin, Sinjar and Mosul receive more rainfall than stations in the Central and Southern part of the country. In general, rainfall increases from the south and south-west towards the north and north-east. Also, Fig. 11.5 shows the rainfall distribution in the country. This feature makes agriculture without irrigation virtually impossible in the Central and Southern part of the country, the serious hazard limit being approximately the 240 mm isohyet according to UNESCO.[16]

The monthly rainfall distribution reveals that January is the

Table 11.12 The Mean Monthly, Seasonal and Annual Rainfall in Selected Stations in Iraq

Stations	Latitude	Longitude	Altitude	Mean Monthly Precipitation (mm)								Mean Seasonal Precipitation (mm)				Mean Annual	No.of cases (years)
				Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Oct-Nov. Aut.	Dec-Feb. Wint.	Mar.-May Sprg.	June-Sept. Sum.		
Salahuddin	36°37'	44°13'	1,088	13.5	90.1	96.5	109.7	92.5	106.2	89.3	53.2	103.6	298.7	248.7	-	651.0	-
Sinjar	36°19'	41°50'	538	8.8	31.6	70.8	77.7	60.7	67.0	53.0	33.1	40.4	209.2	153.1	-	402.7	22
Mosul	36°19'	43°09'	223	10.2	36.5	65.6	67.7	64.6	69.6	50.8	24.9	46.7	197.9	145.3	-	389.9	30
Kirkuk	35°28'	44°24'	331	4.3	40.8	58.6	60.7	61.8	75.5	51.0	21.0	45.1	181.1	147.5	-	373.7	30
Khanaqin				4.3	30.6	47.8	62.0	53.7	66.7	37.3	18.2	34.9	163.5	122.2	-	320.6	26
Baiji	34°56'	43°29'	115	1.5	23.5	26.9	34.6	24.2	33.5	25.3	8.5	25.0	85.7	67.3	-	178.0	13
Baghdad	33°20'	44°25'	34	3.7	17.2	22.9	25.3	24.4	22.7	22.3	8.1	20.9	72.6	53.1	-	146.6	30
Basrah	30°33'	47°48'	2	1.0	22.8	30.2	22.8	13.8	20.2	20.4	7.8	23.8	66.8	48.4	-	139.0	30
Hai	32°10'	46°03'	15	3.2	20.3	23.1	24.9	20.8	19.3	18.2	9.5	23.5	68.8	47.0	-	139.3	30
Samawa	31°18'	45°17'	6	2.6	25.1	25.6	17.5	16.8	7.8	9.7	5.2	27.7	59.9	22.7	-	110.3	11
Haditha	34°04'	42°22'	140	7.8	16.5	16.2	17.9	15.2	16.3	9.2	5.9	24.3	49.3	31.4	-	105.0	10
Ana	34°28'	41°27'	150	5.3	9.8	22.5	18.6	16.9	20.4	22.2	5.7	15.1	58.0	48.3	-	121.4	-
Hitt	33°38'	42°50'	58	1.1	25.0	16.0	24.0	15.4	20.7	20.3	7.1	26.1	55.4	48.1	-	129.6	18
Diwaniya	31°59'	44°59'	20	3.9	15.5	20.2	21.2	15.0	16.9	17.8	8.4	19.4	56.4	43.1	-	118.9	30
Habbaniya	33°22'	43°34'	44	2.3	20.2	13.1	27.9	12.0	10.5	19.9	6.2	22.5	53.0	36.6	-	112.1	30
Nasiriya	31°01'	46°14'	3	2.2	16.8	20.4	19.2	13.4	15.8	16.6	7.1	19.0	53.0	39.5	-	111.5	30
Rutba	33°02'	40°11'	615	5.4	13.3	16.3	13.6	13.6	15.4	17.6	15.0	18.7	43.5	48.0	-	110.2	29
Kerbela	32°37'	44°02'	29	0.3	8.9	19.3	16.7	15.9	11.5	18.2	3.9	9.2	51.9	33.6	-	94.7	10
Najaf				7.1	16.2	12.3	22.4	12.9	2.0	12.0	7.0	23.3	47.6	21.0	-	91.9	-
Nukhaib	32°02'	42°15'	305	1.9	7.8	5.4	10.1	5.0	1.5	5.7	2.3	9.7	20.5	9.5	-	39.7	-

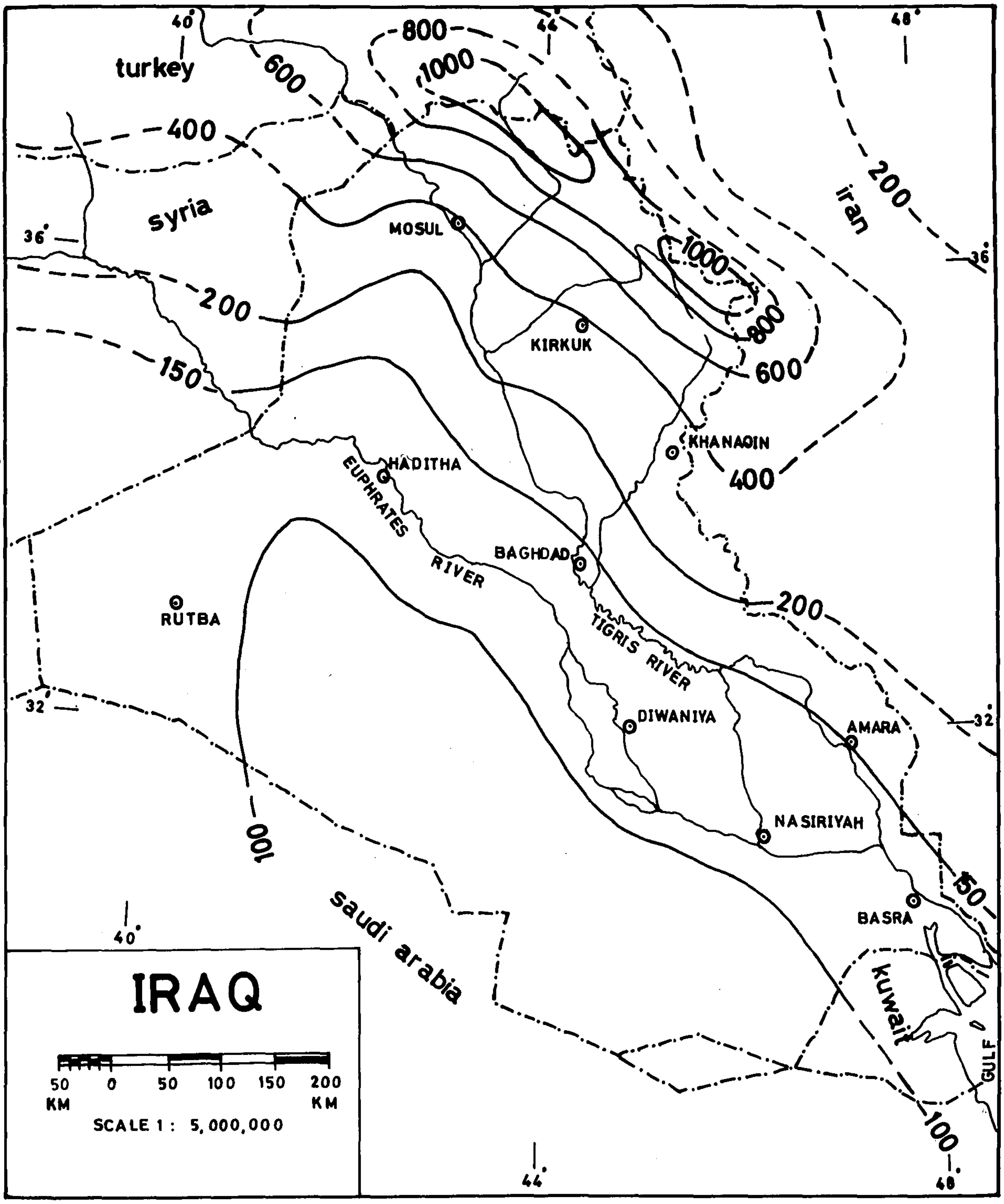
Sources : (1) UNESCO : Iraq - Contributions on Natural Resources Research, Table No.3, p.20.
(2) Thalen, D.C.P.(1979) : The Ecology and Utilization of Shrub Rangelands in Iraq,Dr.W.Junk B.V.-Publishers, The Huge, Table IV-3, p.59.

Table 11.13 The Percentage of Mean Monthly and Seasonal Rainfall to the total Rainfall

Stations	Months								Seasons			Total
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Oct-Nov Autumn	Dec-Jan Winter	Mar-May Spring	
Salahuddin	2.07	13.84	14.82	16.85	14.21	16.31	13.72	8.17	15.91	45.88	38.20	100
Sinjar	2.19	7.85	17.58	19.29	15.07	16.64	13.16	8.22	10.03	51.95	38.02	100
Mosul	2.62	9.36	16.82	17.36	16.57	17.85	13.03	6.39	11.98	50.76	37.26	100
Kirkuk	1.15	10.92	15.68	16.24	16.54	20.20	13.65	5.62	12.07	48.46	39.47	100
Khanagin	1.34	9.55	14.91	19.34	16.75	20.80	11.63	5.68	10.89	51.00	38.11	100
Baija	0.84	13.20	15.11	19.44	13.60	18.82	14.21	4.78	14.04	48.15	37.81	100
Baghdad	2.52	11.73	15.62	17.26	16.64	15.48	15.21	5.53	14.26	49.52	36.22	100
Basrah	0.72	16.40	21.73	16.40	9.93	14.53	14.68	5.61	17.12	48.06	34.82	100
Hai	2.30	14.57	16.58	17.88	14.93	13.85	13.07	6.82	16.87	49.39	33.74	100
Samawa	2.36	22.76	23.21	15.87	15.23	7.07	8.79	4.71	25.11	54.31	20.58	100
Haditha	7.43	15.71	15.43	17.05	14.48	15.52	8.76	5.62	23.14	46.95	29.91	100
Ana	4.37	8.07	18.53	15.32	13.92	16.80	18.29	4.70	12.44	47.78	39.78	100
Hitt	0.85	19.29	12.35	18.52	11.88	15.97	15.66	5.48	20.14	42.75	37.11	100
Diwaniya	3.28	13.04	16.99	17.83	12.62	14.21	14.97	7.06	16.32	47.43	36.25	100
Habbaniya	2.05	18.02	11.69	24.89	10.70	9.37	17.75	5.53	20.07	47.28	32.65	100
Nassiriya	1.97	15.06	18.30	17.22	12.02	14.17	14.89	6.37	17.04	47.53	35.43	100
Rutba	4.90	12.07	14.80	12.34	12.34	13.97	15.97	13.61	16.97	39.47	43.56	100
Kerbela	0.32	9.40	20.38	17.63	16.79	12.14	19.22	4.12	9.71	54.81	35.48	100
Najaf	7.73	17.63	13.38	24.37	14.04	2.17	13.06	7.62	25.35	51.80	22.85	100
Nakhaib	4.79	19.65	13.60	25.44	12.59	3.78	14.36	5.79	24.43	51.64	23.93	100
Average	2.79	13.91	16.38	18.33	14.04	13.98	14.20	6.37	16.69	48.75	34.56	100

Source : Calculated from Table 11.12

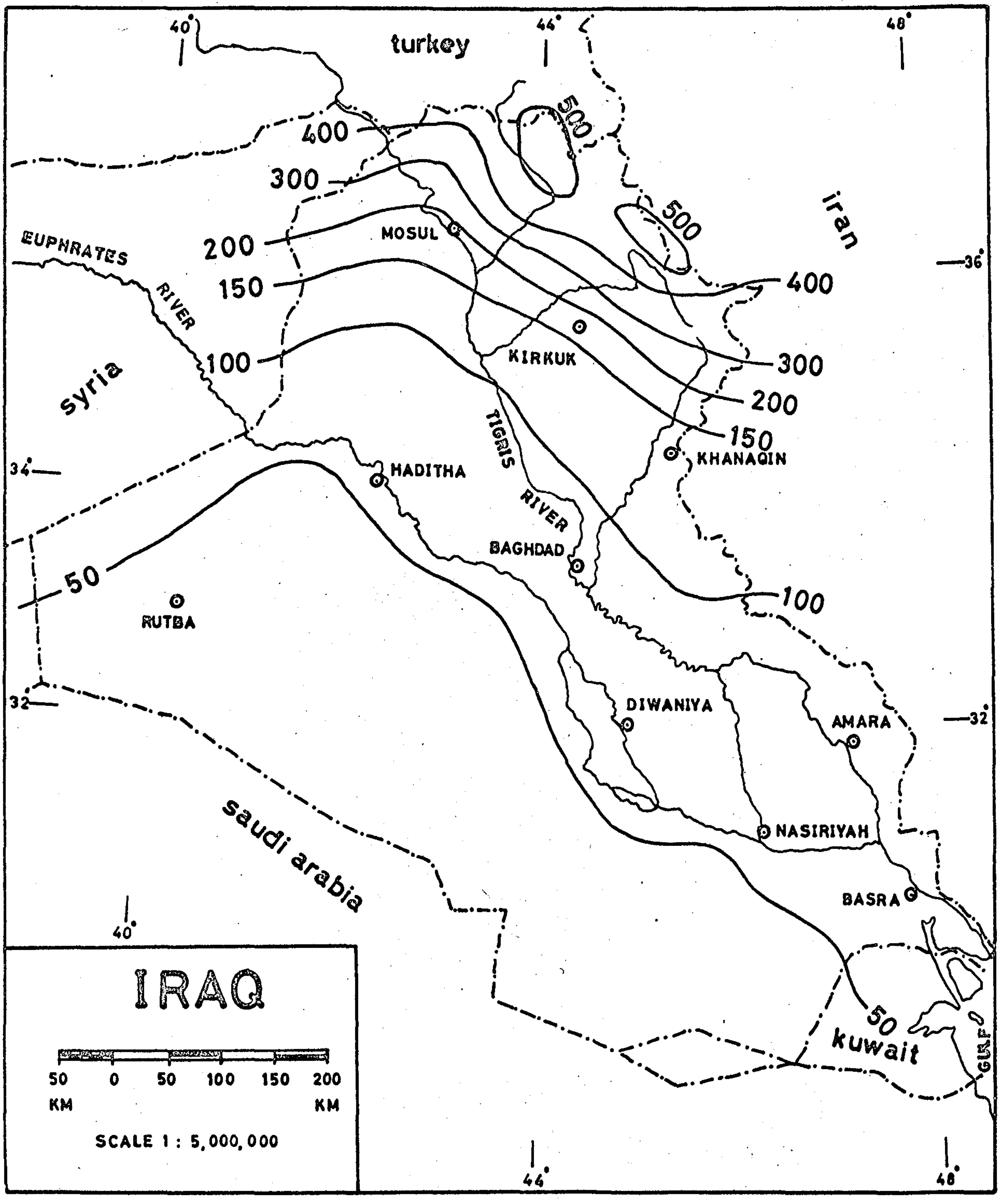
FIG..11.5 MEAN ANNUAL RAINFALL(mm)*



* Based on 15 year's or more data - period 1941-1970.

Source : UNESCO(1976): Iraq: Contributions on Natural Resources Research, UNDP/IRQ/71/545, Paris, p.21.

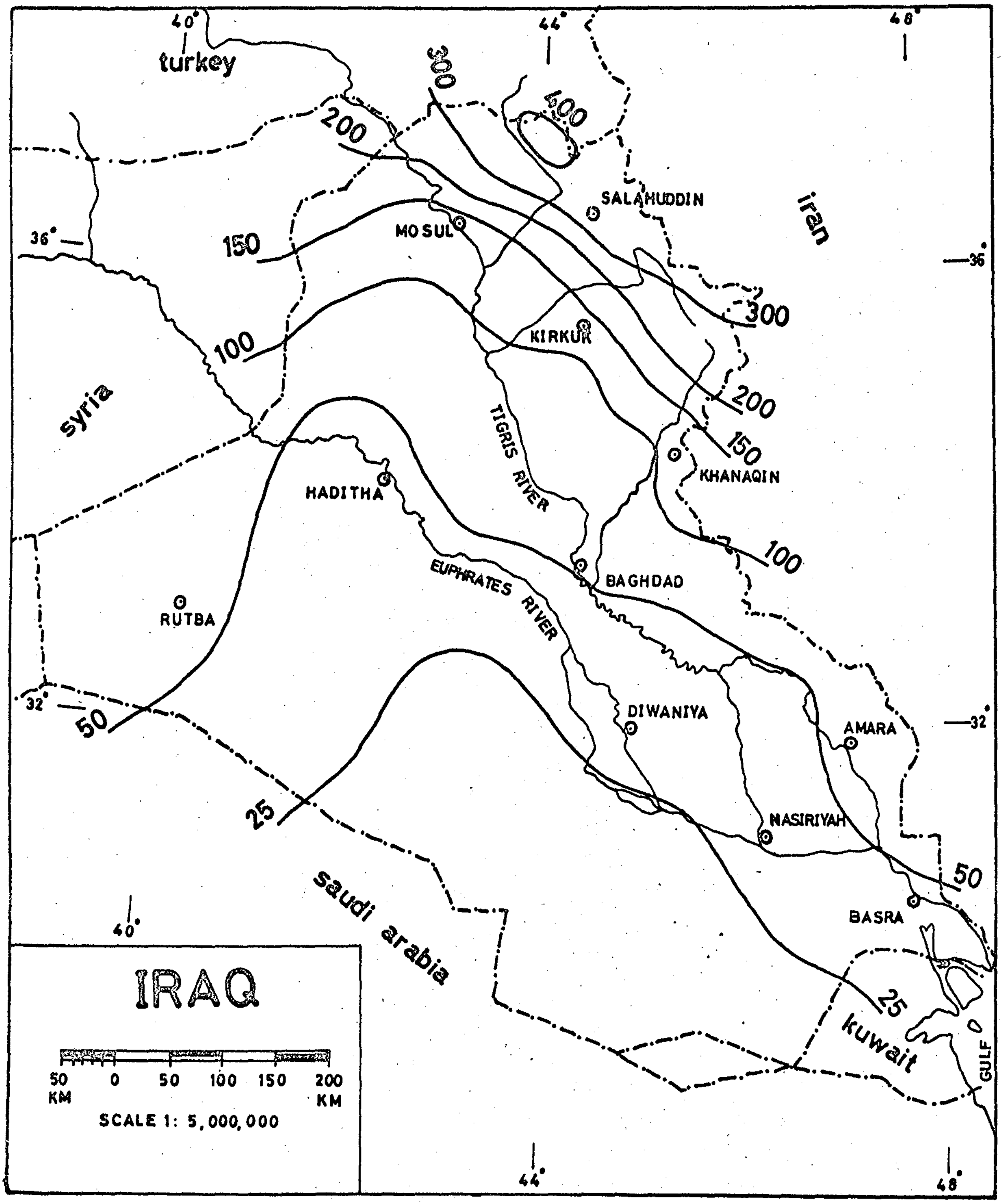
FIG..11.6 MEAN WINTER (ECEMBER - FEBRUARY) RAINFALL(mm)*



* Based on 15 year's or more data - period 1941-1970.

Source : As in Fig. 11.5, p.22.

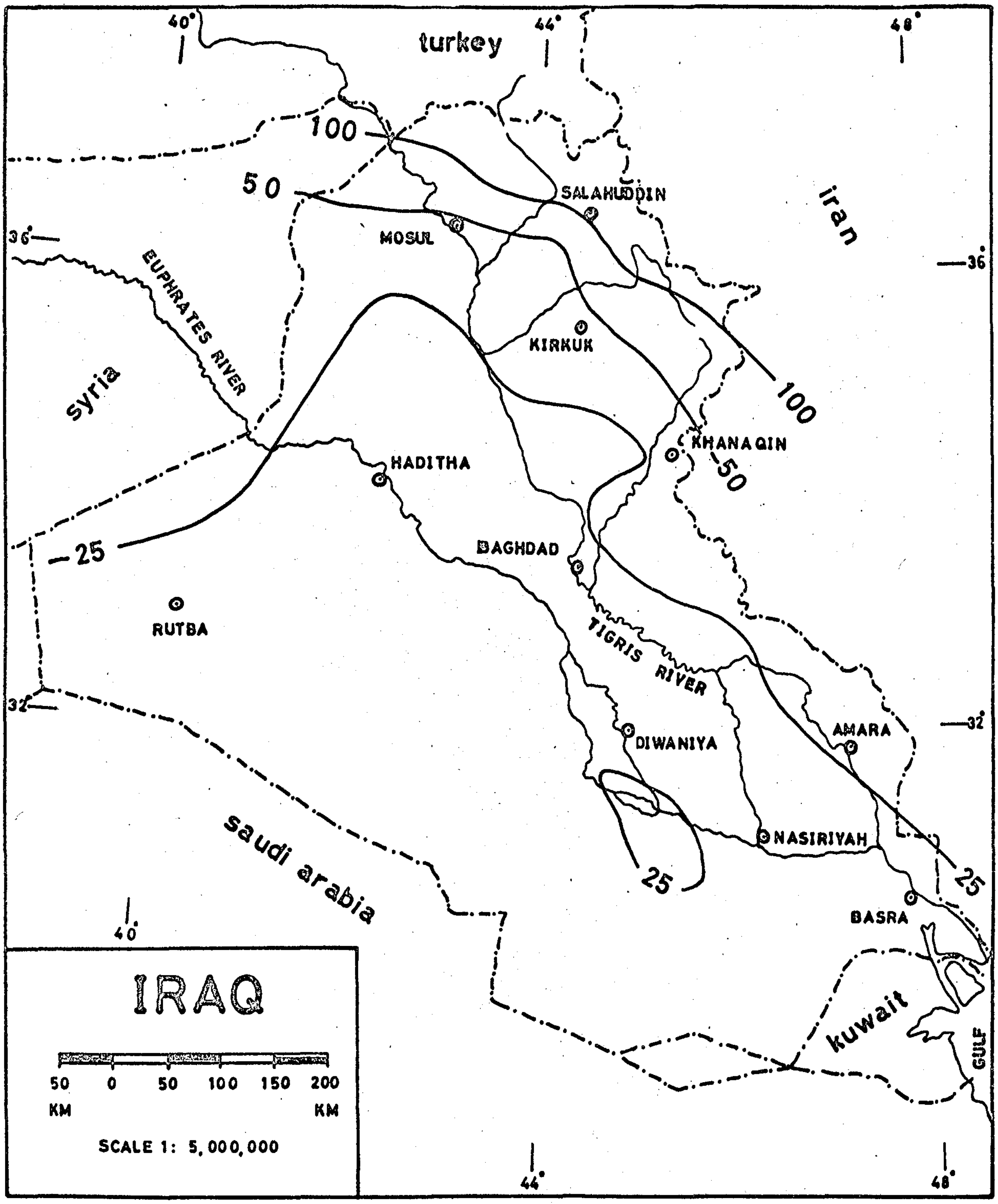
FIG. 11.7 MEAN SPRING (MARCH - MAY) RAINFALL(mm)*



* Based on 15 year's or more data - period 1941-1970.

Source : As in Fig. 11.5, p.23.

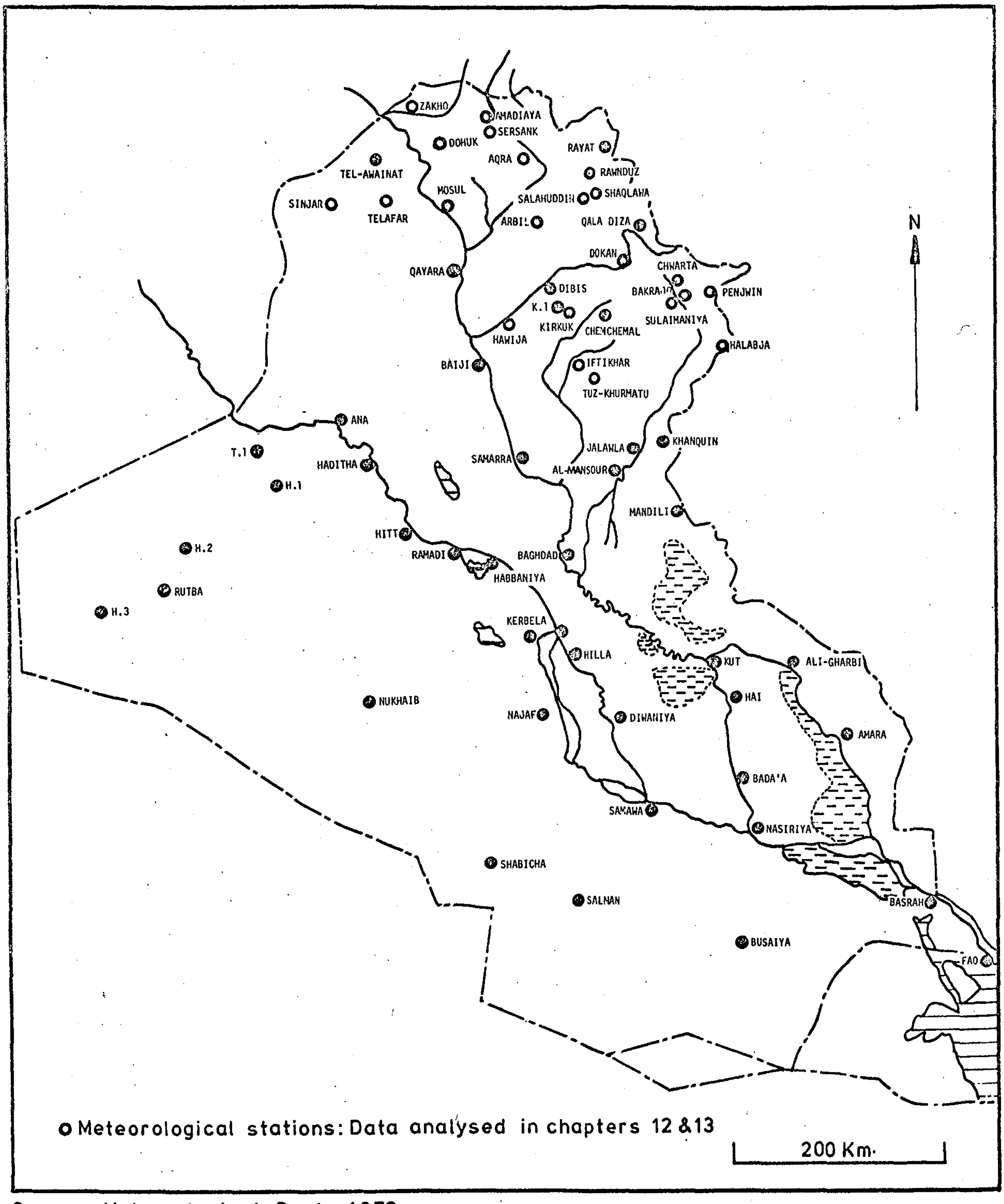
FIG. 11.8 MEAN AUTUAM(OCTOBER-NOVEMBER) R.:INFALL(mm)*



* Based on 15 year's or more data - period 1941-1970.

Source ::As in Fig. 11.5, p.24.

Fig. 11·9 LOCATION OF METEOROLOGICAL STATIONS



Source: Meteorological Dept., 1972

wettest month, followed by December, April, February, March, November, May and October (see Table 11.13). Table 11.13 reveals that almost half of the annual rainfall occurs in the winter season (December - February), more than one third during spring (March - May) and the rest in the autumn (October - November). This means that about 85 per cent of the annual rainfall occurred during the winter and spring seasons. Figs. 11.6, 11.7, and 11.8 show the rainfall distribution, by seasons.

11.8 Precipitation in The Rainfed Area

In order to study precipitation in more detail in the rainfed area, a number of meteorological stations have been selected, each with at least 11 years of observations. Table 11.14 shows the mean, minimum, maximum, standard deviation and the coefficient of variation for all these stations, and some particular points can be made.

1. The mean of annual rainfall of these stations differs slightly from the mean of annual rainfall reported in Table 11.12 because of differences in the periods covered.

2. The stations in the extreme north and north-east at high altitudes have much higher mean annual rainfall than the stations in the foothill areas. Most of the stations in Sulaimaniya and Arbil provinces, except Arbil station itself, come under this category. Also, most of the stations in Nineveh, except Sinjar, Mosul and Telafar, come under this category, and most of these stations are located in the extreme northern portion of Nineveh province which is now called Duhok province.

3. All the stations in Kirkuk province and Sinjar, Mosul and Talafer stations in Nineveh province which have lower mean annual rainfall, are located in the foothill region (see Fig. 11.9). This region is dominated by wheat and barley production (see Table 11.1).

4. Rainfall variability is very important from the agricultural point

Table 11.14 The Minimum, Maximum, Mean, St. Dev. and the Coefficient of Variation of Total Rainfall by Stations in the Rainfed areas* of Iraq (mm.)

Stations	Altitude meter	Latitude	Longitude	No. of Cases	Minimum	Maximum	Mean	Std.Dev.	% Coeff- of variation
Nineveh province									
1 Sinjar	538	36°19'	41°50'	27	139.40	819.10	407.46	164.80	40.45
2 Mosul	223	36°19'	43°09'	27	221.20	643.00	384.61	111.09	28.88
3 Telafar	273	36°22'	42 28'	27	170.60	579.80	324.07	112.85	34.82
4 Aqra	716	36°45'	43°53'	20	446.20	1,503.40	882.27	283.79	32.17
5 Sersank	1,046	36°58'	43°32'	20	323.80	1,727.60	943.61	464.80	49.26
6 Dohuk	860	36°52'	43°02'	20	340.40	1,018.70	588.93	185.44	31.49
7 Amadiya	1,236	37°05'	43°30'	18	535.30	2,040.50	893.79	353.10	39.51
8 Zakho	442	37°08'	42°41'	13	399.80	1,052.40	717.12	177.13	24.70
Kirkuk province									
1 Kirkuk	331	35°28'	44°24'	27	194.80	650.50	384.20	110.28	28.70
2 Hawija	305	35°19'	43°47'	27	115.40	422.20	255.42	81.91	32.07
3 Iftikhar	204	35°03'	44°27'	21	76.20	557.60	243.65	106.56	43.74
4 Tuz-Khurmatu	220	34°53'	44°39'	21	55.60	599.50	253.39	137.55	54.28
Arbil province									
1 Shaqlawa	414	36°24'	44°20'	27	432.20	2,186.60	936.43	360.78	38.53
2 Arbil	1,006	36°11'	44°00'	23	205.50	731.70	436.34	118.61	27.19
3 Rawnduz	1,008	36°37'	44°32'	22	515.70	1,552.50	924.33	257.17	27.82
4 Salahudin	853	36°27'	44°13'	21	125.90	1,007.90	654.46	217.04	33.16
Sulaimaniya prov.									
1 Dokan	670	35°57'	44°58'	26	460.00	1,342.70	799.66	251.66	31.47
2 Sulaimaniya	853	35°33'	45°27'	23	312.00	1,228.80	721.87	209.55	29.03
3 Halabja	724	35°11'	45°59'	19	353.90	1,074.10	627.31	182.94	29.16
4 Bakrajo	750	35°34'	45°23'	20	444.10	1,175.00	733.36	214.93	29.31
5 Penjwin	1,311	35°37'	45°58'	12	715.00	1,863.10	1,201.4	389.47	32.42
6 Chwarta	1,356	35°44'	45°35'	11	436.90	1,266.20	762.57	266.42	34.94

Source : Our Calculation

* There are differences in the mean of annual rainfall of some stations in this Table and Table No. (11.12). These differences are due to number of years under the study.

of view. In general, as the mean of the annual rainfall increases, the rainfall variability coefficient decreases and vice versa. This means rainfall reliability increases as the coefficient of rainfall variation decreases and this is very important for agriculture. Table 11.14 shows the coefficient of rainfall variation for the stations in the rainfed area. Although Mosul and Kirkuk Stations show less variation in rainfall, the mean annual rainfall is not very high, while Penjwin station has the highest mean annual rainfall and also has a relatively high coefficient of rainfall variation. A study carried out by UNESCO shows that the coefficient of the rainfall variation is higher in the Central and Southern parts of the country.[17] Fig.11.10 shows the relation between mean annual rainfall and the coefficient of rainfall variation.

Relating the mean annual rainfall and the rainfall variation to agriculture, the UNESCO study recommended that a minimum of 240 mm. of annual rainfall and 37.5 per cent of variation could be accepted as a theoretical limit requirement for dry land farming in the Middle East region.[18] With the exception of a few stations in the rainfed area, it is safe to assume that rainfall is reliable, according to these criteria, for dry farming in the rainfed area of Northern Iraq.[19]

11.9 Rainfall Distribution in The Rainfed Area

It has already been mentioned that almost 85 per cent of the annual rainfall occurs during winter and spring seasons for the whole country and the rainfed area shares almost the same kind of seasonal rainfall distribution. Table 11.15 shows the seasonal rainfall in the rainfed area. It is clear that about 88 per cent of the rainfall occurs in the winter and spring seasons. Variation in the seasonal rainfall is clearly very important in relation to agriculture. For example, autumn rainfall may affect decisions controlling the area cultivated or sown, whilst

FIG. 11.10 THE RELATIONSHIP BETWEEN ANNUAL RAINFALL & VARIATION

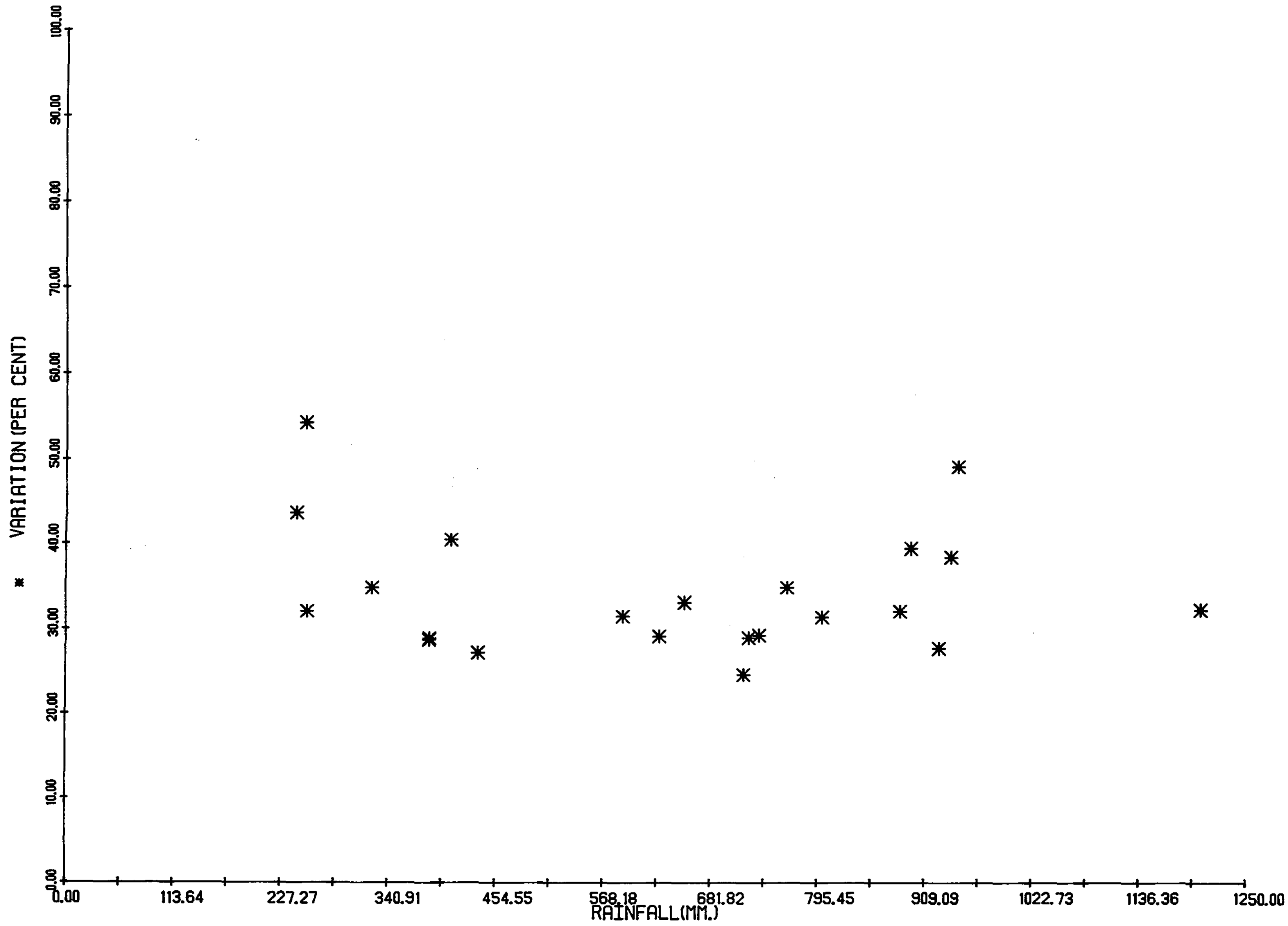


Table 11.15 — Distribution of Seasonal Rainfall in the Rainfed Area

	Autumn Oct-Nov mm.	%	Winter Dec-Feb mm.	%	Spring Mar.-May mm.	%
Sinjar	37.87	9.27	205.67	50.36	164.83	40.36
Mosul	42.70	11.10	187.32	48.70	154.64	40.20
Telafar	36.09	11.14	157.89	48.72	130.09	40.14
Agra	118.13	13.39	447.66	50.74	316.52	35.87
Sersank	126.52	13.30	441.42	46.38	383.71	40.32
Duhok	73.86	12.54	301.52	51.20	213.56	36.26
Amadiya	118.96	13.31	397.17	44.44	377.67	42.25
Zakho	84.18	11.74	349.63	48.76	283.27	39.50
Kirkuk	40.25	10.48	190.46	49.57	153.48	39.95
Hawija	29.19	11.43	121.61	47.61	104.62	40.96
Ftikhar	29.48	12.10	119.15	48.90	95.02	39.00
Tuz-Khurmatu	26.68	10.53	121.37	47.90	105.34	41.57
Shaqlawa	104.65	11.18	510.41	54.51	321.37	34.31
Arbil	43.66	10.00	218.95	50.18	173.73	39.82
Rawanduz	115.07	12.45	436.43	47.22	372.83	40.33
Salahuddin	102.89	15.72	313.44	47.89	238.13	36.39
Dokan	91.26	11.41	394.90	49.38	313.50	39.21
Sulaimaniya	87.36	12.32	332.75	46.94	288.79	40.74
Halabja	83.08	13.24	315.73	50.33	228.51	36.43
Bakrajo	98.14	13.36	329.62	44.89	306.57	41.75
Penjwin	131.95	10.98	625.22	52.03	444.59	36.99
Chwarta	79.55	10.43	397.30	52.10	285.73	37.47
Average	77.34	12.09	314.35	49.14	248.02	38.77

Source : Calculated from Table 11.16

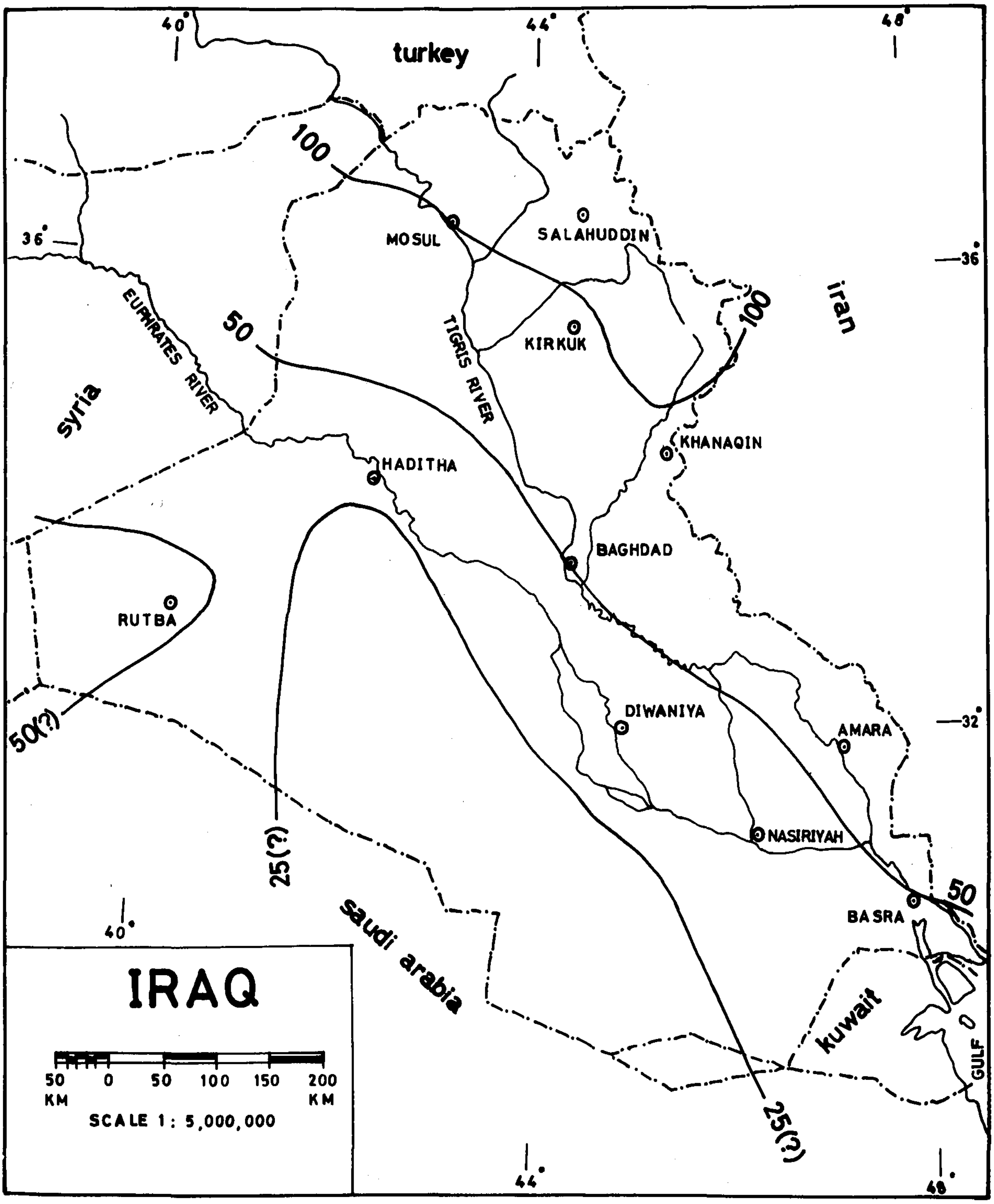
winter rainfall may affect decisions to apply fertilizers or other inputs. The same could be said for the spring rainfall. As far as the rainfed area of Iraq is concerned, analysis shows that autumn and spring rainfalls are more variable than those of winter.

The mean monthly rainfall, however, is not less important than seasonal distribution. Monthly rainfall affects farmers' decisions as well as the growth of the plants, and consequently will affect the yield and total production of a particular crop. Table 11.16 shows the mean monthly rainfall in the rainfed area. It is clear that the monthly rainfall distribution is not the same as the national average or even the seasonal regime. The wettest month in this region is March with a mean monthly rainfall of 112.89 mm, followed by February, December, January, April, November, May and October. Except for years when heavy autumn showers occur in October, precipitation significant enough for agriculture usually starts in November and continues until the end of April.[20] For mean, minimum, maximum, standard deviation and the coefficient of variation for each month in the selected stations, see Appendix H, Table H.7 for details.

For the daily rainfall, UNESCO carried out an investigation to study the frequency of daily rainfall for various stations. Table 11.17 shows the mean frequency of daily rainfall for various class intervals. Broadly speaking, it can be seen that over 80 per cent of rainy days in the rainfed areas have precipitation of 10 mm. or lower whilst in the rest of the country, 90 per cent of the rainy days have precipitation of 10 mm. or lower.[21]

Also, Fig. 11.11 shows the annual mean of rainy days. It is clear the north receives more rain than the rest of the country. Nonetheless, Kaul reported that the mean number of days per year with rainfall 10 mm. and less is about 40 in the Mosul area and 15 in the

FIG. 11.11 ANNUAL MEAN NUMBER OF RAINY DAYS[x]



Source : As in Fig. 11.5, p.33.

x Based on meagre and widely varying length of data series of which several are wrong. Yet the above analysis is presented to show a rough spatial distribution of this important parameter as best as available data permit.

Table 11.16 Mean Monthly Rainfall (mm) at Stations within the Rainfed Area

Stations	No. of cases	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
Sinjar	27	8.47	29.40	67.96	73.82	63.89	68.07	60.59	36.17
Mosul	27	9.73	32.97	60.29	62.79	64.24	72.10	56.68	25.86
Telafer	27	5.44	30.65	51.49	55.55	50.85	58.29	49.50	22.30
Aqra	20	24.13	94.00	145.63	146.30	155.73	148.30	126.84	41.38
Sersank	20	19.22	107.30	145.59	134.81	161.02	170.33	151.45	61.93
Duhok	20	17.21	56.65	110.17	105.16	86.19	124.50	69.62	19.44
Amadiya	18	20.01	98.95	142.31	116.31	138.55	159.73	162.10	55.84
Zakho	13	19.85	64.33	131.41	105.92	112.30	117.41	114.54	51.32
Kirkuk	27	4.12	36.13	60.71	62.09	67.66	72.75	56.69	24.04
Hawija	27	3.17	26.02	40.28	40.98	40.35	42.01	45.43	17.18
Ftikhar	21	2.51	26.97	40.31	40.96	37.88	41.51	42.41	11.10
Tuz-Khurmatu	21	2.93	23.75	46.06	36.66	38.65	50.58	40.73	14.03
Shaqlawa	27	16.42	88.23	169.82	139.68	200.91	161.52	122.04	37.81
Arbil	23	5.57	38.09	66.91	73.04	79.00	79.72	58.38	35.63
Rawanduz	22	23.62	91.45	125.90	133.48	177.05	165.42	140.27	67.14
Salahuddin	21	11.70	91.19	105.04	111.80	96.60	94.41	93.77	49.95
Dokan	26	6.47	84.79	116.47	133.68	144.75	130.64	130.73	52.13
Sulaimaniya	23	14.47	72.89	102.05	115.47	115.23	125.33	118.72	44.74
Halabja	19	9.46	73.62	99.74	117.89	98.10	106.62	91.77	30.12
Bakrajo	20	9.98	88.16	106.45	116.11	107.06	123.69	128.46	54.42
Penjwin	12	13.98	117.97	205.37	181.46	238.39	226.75	161.41	56.43
Chwarta	11	5.62	73.93	110.56	140.33	146.41	143.81	105.23	36.69

Source : Our Calculation

Table 11.17 Mean Frequency of Daily Rainfall for Various Class Intervals

Stations	Class Intervals					Any Rain	No. of years data used
	Tr-10 mm.	10.1-30 mm.	30.1-50 mm.	50.1-1.80mm	80 mm.		
Mosul	77.72	20.56	1.37	0.09	0.00	99.74	30
Kirkuk	65.52	9.11	1.43	0.17	0.07	76.30	30
Khanaqin	43.67	6.64	0.74	0.49	0.04	51.58	30
Baghdad	53.49	3.40	0.34	0.09	0.00	57.32	30
Rutba	55.58	3.52	0.17	0.00	0.00	59.27	30
Hai	44.15	3.13	0.27	0.03	0.00	47.58	30
Diwaniya	32.27	2.59	0.40	0.07	0.00	38.33	30
Nassiliya	37.46	2.27	0.47	0.30	0.00	40.50	30
Basrah	47.35	3.69	0.40	0.09	0.03	52.16	30

Source : UNESCO, 1975 : Iraq - Contributions on natural resources research, Table No.6, p.32.

area west of Sinjar.[22] These figures are very much below the figures reported by UNESCO.

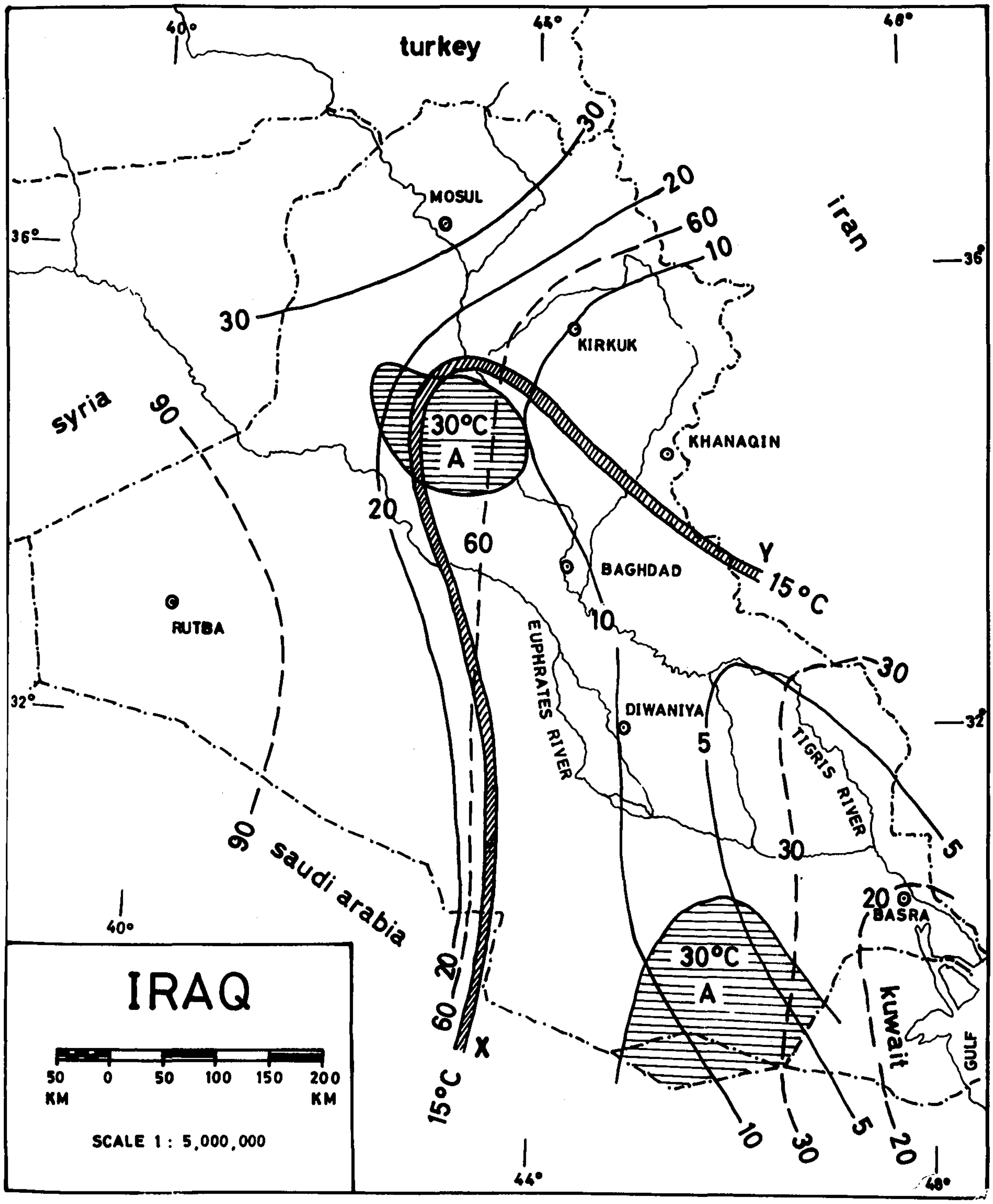
11.10 Air Temperature

Plant growth is not only affected by rainfall, but also by air temperatures which affect not only the growth of the plant itself directly, but also affect soil temperature and moisture, evaporation and evapotranspiration. In this section, the temperature characteristics will be reviewed for the whole country as well as the temperature conditions during the growing seasons in the rainfed area.

11.10.1 Minimum Temperature : Temperatures become crucial for plant growth at a threshold level, above which growth is vigorous, and below which it slows down, complete cessation or plant death at freezing point. There is no fixed threshold level for plant growth because that depends on other circumstances, but its range varies between 3 -5^{o}C. As far as Iraq is concerned, the threshold point is set at 5^{o}C and the occurrence of such low temperatures is very important to agriculture. [23] Fig.11.12 shows the frequency of days of minimum temperature of 5^{o}C or less for the whole country. It is difficult to assess precisely the extent of damage due to this low temperature without more agroclimatological observations.

Here minimum temperature observations during the growing season of winter crops for two stations at the rainfed area have been considered. Tables 11.18 and 11.19 show the mean, minimum, maximum, standard deviation and the coefficient of variation of the minimum temperature at Mosul and Kirkuk stations. Table 11.18 shows that January is the coldest month in Kirkuk with a mean minimum temperature of 4.56^{o}C. In Mosul station, January is also the coldest month with mean minimum temperature of 2.17^{o}C. Temperaturesbelow the threshold point also extend into

FIG. 11.12 MEAN ANNUAL NUMBER OF DAYS WITH MINIMUM TEMPERATURE[x]



Source : As in Fig. 11.5, p.41.

x (a) $0^{\circ}C$ or less(by Full Lines) and (b) $5^{\circ}C$ or less(by Broken Lines).

NOTE 1. AVERAGE TEMPERATURE OF DAY IN MARCH SOUTH OF LINE X-Y SHOWN BY ▨ IS 15 °C OR SLIGHTLY MORE; WHILE TO ITS NORTH IT IS LESS.

2. AVERAGE TEMPERATURE OF DAY IN MAY IS 30 °C IN THE HATCHED AREAS MARKED "A" ; WHILE IT IS LESS THAN 30 °C IN REST OF THE COUNTRY.

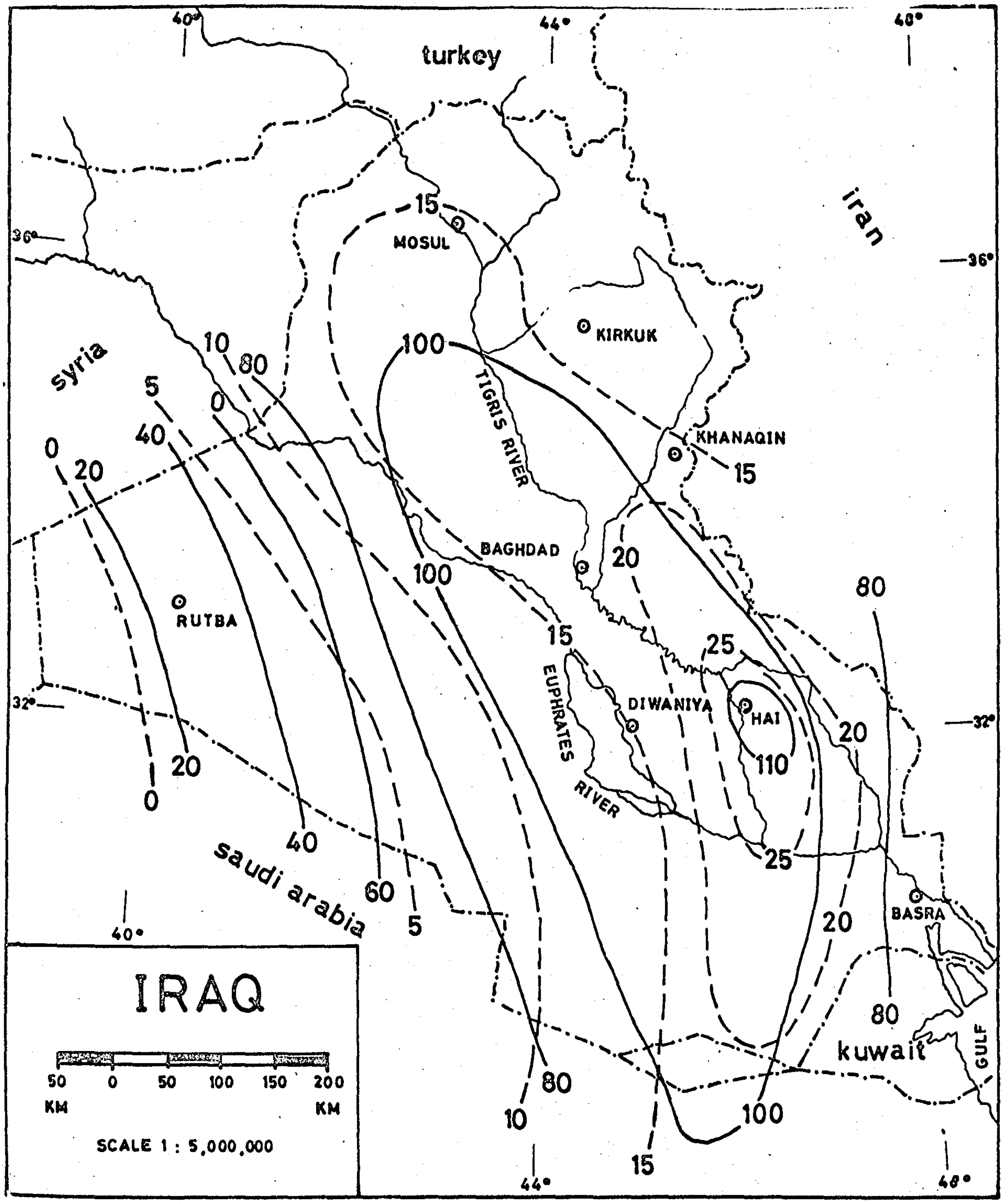
3. AVERAGE TEMPERATURE OF DAY IN APRIL FOR ENTIRE COUNTRY IS > 15 °C BUT CONSIDERABLY LESS THAN 30 °C.

December and February (see Tables 11.18 and 11.19). Moreover an analysis of the coefficient of variation reveals that as the temperatures drop the coefficient of variation increases. This means that the annual variation of the low temperature is very high. The coefficient of variation of minimum temperatures is particularly high at Kirkuk station.

11.10.2 Maximum (High) Temperature : Generally speaking, the range between minimum temperature and maximum temperature diurnally and between Winter and summer is very high in Iraq. In fact, high temperature is not as severely damaging on the plant growth during the winter season as for the summer crops. High summer temperatures, mainly due to high radiation and long duration of sunshine, may seriously affect the plant growth, but in this study, maximum temperature can be considered only in relation to the growing season of the winter crops. Tables 11.20 and 11.21 show the mean, minimum, maximum, standard deviation and the coefficient of variation of maximum temperatures at Mosul and Kirkuk stations. It is clear that January has the lowest mean of maximum temperature. Although the coefficient of variation increases as temperatures drop, this increase is very much less than the coefficient of minimum temperature. In other words, maximum temperatures are more stable than minimum temperatures. Fig. 11.13 shows the frequency of days with maximum temperatures above 40°C. The average mean of monthly temperature (maximum and minimum) reveals that January has the lowest temperatures and the coefficient of variation increases as temperature decreases (see Tables 11.22 and 11.23).

11.11 Soil Temperature : Many meteorological observations are available but often only for short periods; this is especially true for records of soil temperature. Data are available only for six years and for one station (Mosul) in the rainfed area, and therefore soil temperature cannot be used for further analysis. Table 11.24 shows

FIG. 11.13 MEAN ANNUAL NUMBER OF DAYS WITH MAXIMUM TEMPERATURE[x]



Source : As in Fig. 11.5, p.43.

x Equal to or more than:

a) 40°C -Full lines;

b) 45°C -Broken lines.

Table 11.18 The Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Average Monthly Minimum Temperature (°C) at Kirkuk Station in the Rainfed Area During the Growing Season

Month	No. of cases	Min.	Max.	Mean	Std.Dev.	% of co-eff. of var.
October	27	14.10	20.30	17.47	1.47	8.41
November	27	8.70	14.20	11.14	1.26	11.31
December	27	3.30	8.00	6.12	1.24	20.26
January	27	0.00	7.90	4.56	1.75	38.38
February	27	2.20	8.70	5.80	1.64	28.28
March	27	5.30	11.20	8.79	1.50	17.07
April	27	11.00	16.50	13.54	1.27	9.38
May	27	15.60	21.90	18.99	1.58	8.32
Average Season Min.Temp.	27	9.70	12.0	10.81	0.63	5.83

Source : Our Calculation

Table 11.19 The Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Average Monthly Minimum Temperature (°C) at Mosul Station in the Rainfed Area During the Growing Season

Month	No. of cases	Min.	Max.	Mean	Std.Dev.	% of co-eff. of var.
October	27	7.30	15.40	11.98	2.08	17.36
November	27	3.70	9.60	6.91	1.42	20.55
December	27	- .80	6.90	3.15	1.61	51.43
January	27	-2.60	5.40	2.17	1.84	84.79
February	27	- .70	6.30	3.48	1.71	49.14
March	27	3.90	9.80	6.64	1.52	22.89
April	27	9.40	12.90	10.85	.99	9.12
May	27	11.60	19.20	15.49	1.66	10.72
Average Season Min.Temp.	27	6.30	9.60	7.60	.87	11.45

Source : Our Calculation

Table 11.20 The Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Average Monthly Maximum Temperature (^oC) at Kirkuk Station in the Rainfed Area During the Growing Season.

Month	No. of cases	Min.	Max.	Mean	Std.Dev.	% of co-eff. of var.
October	27	27.90	34.40	32.02	1.67	5.22
November	27	19.20	28.30	22.78	1.94	8.52
December	27	12.90	19.10	16.12	1.84	11.41
January	27	7.80	18.90	13.66	2.45	17.94
February	27	11.30	19.10	15.65	2.07	13.23
March	27	15.80	24.10	19.68	1.81	9.20
April	27	21.60	29.60	25.64	2.19	8.54
May	27	21.50	35.80	32.56	2.99	9.18
Average season Max.Temp.	27	20.50	23.90	22.33	.95	4.26

Source : Our Calculation

Table 11.21 The Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Average Monthly Maximum Temperature (^oC) at Mosul Station in the Rainfed Area During the Growing Season

Month	No. of cases	Min.	Max.	Mean	Std.Dev.	% of co-eff. of var.
October	27	26.10	34.60	31.44	2.06	6.55
November	27	18.80	27.00	21.94	1.77	8.07
December	27	11.30	18.40	14.70	1.83	12.45
January	27	7.40	17.30	13.00	2.34	18.00
February	27	11.20	18.90	15.34	1.99	12.97
March	27	14.00	22.80	19.26	2.01	10.44
April	27	21.70	36.60	25.63	3.06	11.94
May	27	22.80	36.30	32.28	2.83	8.77
Average season Max.Temp.	27	19.90	24.10	21.71	1.06	4.88

Source : Our Calculation

Table 11.22 The Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Average Monthly Mean Temperature (C°) at Kirkuk Station in the Rainfed Area During the Growing Season

Month	No. of cases	Min.	Max.	Mean	St.Dev.	% of co-eff. of var.
October	27	21.70	27.40	24.78	1.37	5.53
November	27	14.50	21.30	17.01	1.51	8.88
December	27	8.30	13.30	11.15	1.45	13.00
January	27	4.40	13.40	9.14	1.95	21.33
February	27	6.80	13.50	10.76	1.79	16.64
March	27	10.60	17.30	14.27	1.54	10.79
April	27	16.60	23.00	19.64	1.66	8.45
May	27	19.00	28.90	25.79	2.14	8.30
Average season Temp.	27	15.20	17.90	16.57	.766	4.62

Source : Our Calculation

Table 11.23 The Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Average Monthly Mean Temperature (C°) at Mosul Station in the Rainfed Area During the Growing Season

Month	No. of cases	Min.	Max.	Mean	St.Dev.	% of co-eff. of var.
October	27	19.40	24.20	21.77	1.39	6.38
November	27	11.90	18.10	14.43	1.27	8.80
December	27	5.70	11.10	8.93	1.38	15.45
January	27	3.10	11.20	7.61	1.84	24.18
February	27	5.50	11.80	9.41	1.69	17.96
March	27	9.70	15.00	13.09	1.49	11.38
April	27	11.40	23.40	17.90	2.13	11.90
May	27	19.90	26.60	23.91	1.63	6.82
Average season Temp.	27	13.30	16.00	14.64	.74	5.05

Source : Our Calculation

Table 11.24 Mean Monthly Soil Temperature (C^o) at Different Depths During the Growing Season at Mosul Station*

Month	Time 6 a.m.					Time 12 a.m.				
	5 cm	10 cm	20 cm	50 cm	100 cm	5 cm	10 cm	20 cm	50 cm	100 cm
October	18.2	19.4	22.6	24.3	25.5	27.1	24.0	23.3	24.4	25.5
November	10.5	11.9	14.6	18.1	20.6	16.3	15.1	14.7	18.0	20.5
December	5.2	6.6	8.2	12.2	15.6	9.3	8.8	8.6	12.2	15.5
January	3.1	4.4	5.6	9.1	11.8	7.8	6.7	6.0	9.2	11.9
February	4.9	6.0	6.8	9.3	11.9	10.8	9.1	7.6	9.3	11.0
March	9.7	10.5	11.5	12.7	13.1	16.7	14.4	12.3	12.8	13.0
April	15.6	15.6	16.3	16.8	16.1	24.0	21.1	17.7	16.7	16.2
May	21.9	21.6	22.2	21.6	20.2	31.4	27.7	23.6	21.6	20.2

* Average of Five years

Source : calculated from data obtained from the Meteorological office.

soil temperatures (C) at various depth at 6 a.m. and 12 a.m. local time. It is clear that variation between 6 a.m. and 12 a.m. at 20, 50, 100 cm. depths is negligible. The lowest soil temperature at all depths was recorded in January.

11.12 Evaporation and Potential Evapotranspiration

Evaporation and potential evapotranspiration are very crucial for agriculture in general and for agriculture in the rainfed area in particular. In the latter, rainfall constitutes the water-supply, while water loss occurs in the form of evaporation and evapotranspiration, runoff and seepage. The difference between water-supply and water-loss is assumed to be stored in soil as soil moisture. The availability of the latter is very significant for the plant growth during the growing season.

Meteorological class A pans are used to estimate evaporation in Iraq. Evaporation generally increases as temperature increases and Table 11.25 shows the mean monthly evaporation for 11 stations throughout the country. It is clear that evaporation reaches its seasonal peak in July. It also appears that evaporation rates in the South are lower than in the Central and Northern zones of the country throughout the year, this because of the higher humidity levels.

Penman's method has been used to estimate potential evapotranspiration in Iraq for a number of stations and Table 11.26 shows potential evapotranspiration for some of these. It is clear that potential evapotranspiration is lower at northern stations such as Mosul, Kirkuk and Salahaddin than at other stations in other parts of the country (See Fig.11.14).

Water availability to crop plants can be assumed from the climatic point of view to be the difference between water gain and

Table 11.25 Evaporation (mm), Monthly Normal for Iraqi Meteorological Stations Generally Starting 1967-1974

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Sinjar	A-	70.6	76.6	143.4	178.7	315.1	449.1	513.9	488.7	351.3	238.7	102.2	64.0
	B-	4	4	3	4	4	4	4	4	4	4	4	4
Mosul	A-	64.8	86.3	134.7	191.5	300.2	398.2	500.8	532.2	350.2	208.9	106.0	61.5
	B-	8	8	8	8	8	8	8	7	7	7	8	8
Kirkuk	A-	50.2	64.1	104.6	137.8	254.2	258.0	399.6	365.4	277.3	184.2	69.4	48.8
	B-	8	8	8	8	8	8	8	8	8	8	8	8
Ana	A-	44.4	68.4	130.0	179.4	281.5	409.3	480.3	432.0	276.9	180.1	81.8	46.0
	B-	6	6	7	7	6	6	6	7	7	7	8	8
Rutbah	A-	65.3	96.2	177.3	268.3	327.3	475.3	573.4	459.5	405.3	267.2	131.6	78.8
	B-	6	7	7	6	7	7	7	7	6	6	7	7
Baghdad	A-	73.9	99.3	184.5	261.3	403.8	522.8	600.5	533.0	370.5	247.0	134.6	61.4
	B-	7	8	8	8	8	8	8	8	8	8	8	6
Najaf	A-	65.4	77.9	146.1	211.0	300.1	409.8	470.0	409.4	296.5	198.4	105.9	59.6
	B-	8	8	8	8	8	8	8	8	8	8	8	8
Diwaniya	A-	51.5	70.7	125.2	170.2	259.7	336.1	390.4	357.7	274.0	188.9	99.8	64.2
	B-	8	8	8	8	8	8	8	8	8	8	8	8
Nasiriya	A-	53.3	73.8	139.7	185.5	292.0	320.0	373.9	361.5	283.9	187.1	94.9	57.6
	B-	8	8	8	8	8	7	8	8	7	8	8	8
Amarah	A-	76.1	98.2	191.5	259.7	450.0	657.8	703.4	590.1	496.5	276.2	166.7	79.5
	B-	3	3	3	3	3	4	4	4	4	4	4	4
Basrah	A-	62.4	77.3	141.8	184.0	249.8	267.1	291.6	274.5	213.4	158.4	87.8	62.8
	B-	8	8	8	8	8	8	8	8	8	8	8	8

NOTES :
1. A- Represents monthly normals of evaporation in millimetres
2. B- Represents No. of Recorded years.
3. The Information is from Evaporation Pan Class " A ".

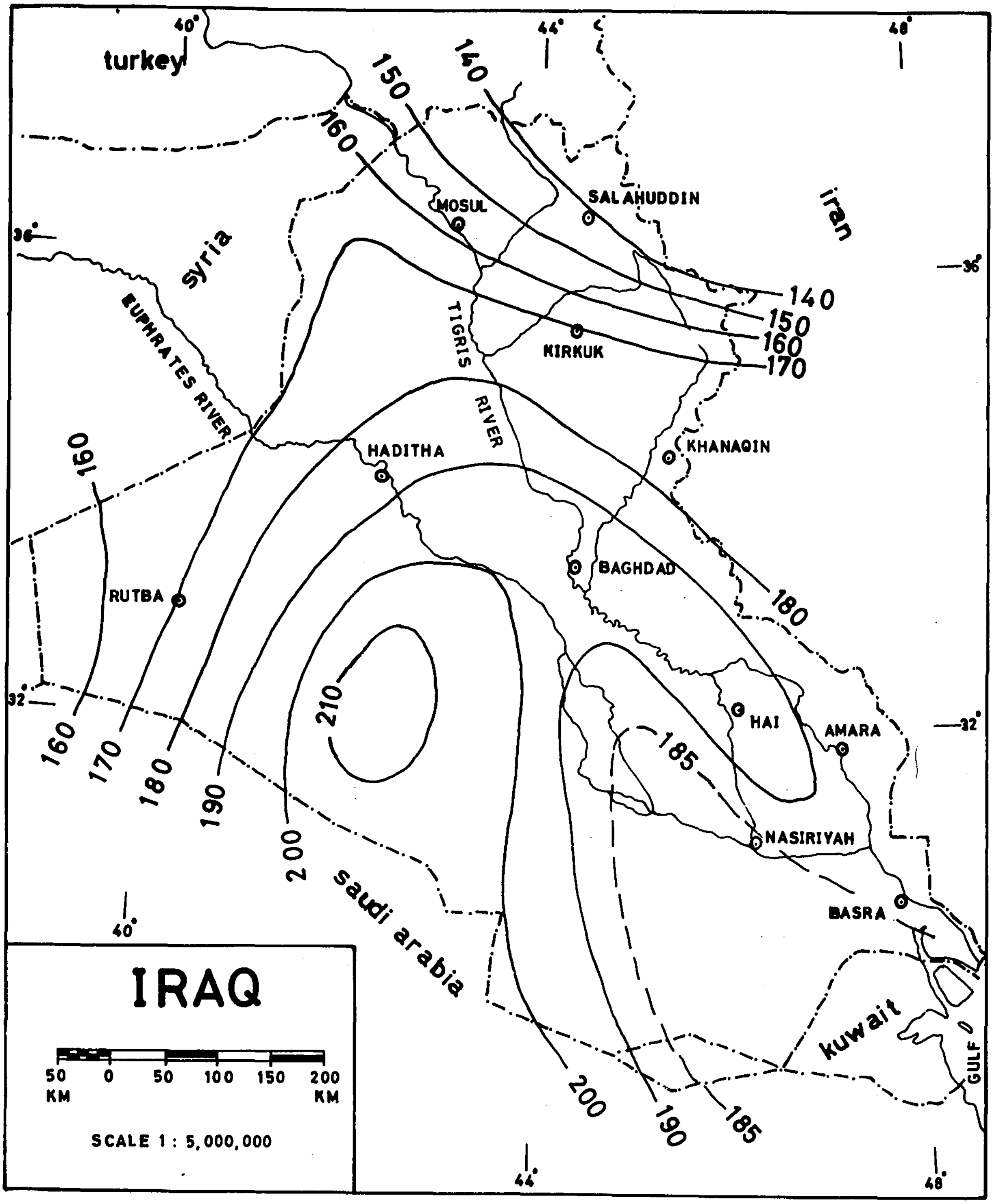
Source : Meteorological Dept. of Iraq.

Table 11.26 Monthly, Seasonal and Annual Mean Potential Evapotranspiration (mm)

Station	MONTHS												SEASONS				Annual	Remarks
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Autm.	Wint.	Spr.	Summ.		
Mosul	99.4	46.6	23.1	27.0	46.0	82.1	124.8	195.3	248.0	266.1	251.0	172.0	146.0	96.1	402.9	937.1	1581.4	By Penman's method using long series mean data
Baghdad	137.6	72.1	42.3	47.6	74.6	125.7	170.9	235.1	294.9	304.4	219.1	197.8	209.7	164.5	531.7	1016.2	1922.1	
Basrah	135.2	76.3	48.1	51.4	75.3	126.5	164.5	221.2	256.3	259.3	242.3	189.0	211.5	175.8	512.2	946.9	1846.4	
Kirkuk	131.0	61.0	30.0	35.0	49.0	85.0	148.0	223.0	276.0	279.0	219.0	208.0	192.0	114.0	456.0	982.0	1744.0	Adjusted Thornthwaite's values by using Penman value of nearest homo-climatic station as guide; Long series data mean used
Khanaqin	135.0	61.0	33.0	38.0	65.0	89.0	161.0	247.0	289.0	293.0	277.0	193.0	196.0	136.0	497.0	1052.0	1881.0	
Ana	105.0	51.0	23.0	34.0	62.0	126.0	190.0	236.0	264.0	272.0	240.0	198.0	156.0	119.0	552.0	974.0	1801.0	
Rutbah	133.0	60.0	44.0	45.0	65.0	116.0	155.0	192.0	241.0	266.0	209.0	170.0	193.0	154.0	463.0	886.0	1696.0	
Habbaniya	133.0	61.0	44.0	43.0	73.0	125.0	170.0	235.0	298.0	329.0	296.0	194.0	194.0	160.0	530.0	1117.0	2001.0	
Najaf	129.0	61.0	30.0	32.0	57.0	115.0	143.0	198.0	303.0	312.0	300.0	221.0	190.0	119.0	456.0	1136.0	1901.0	
Hai	150.0	70.0	41.0	36.0	53.0	98.0	136.0	191.0	305.0	310.0	300.0	228.0	220.0	130.0	425.0	1143.0	1918.0	
Nassiriya	138.0	68.0	42.0	59.0	64.0	115.0	155.0	205.0	287.0	256.0	255.0	208.0	206.0	165.0	475.0	1006.0	1852.0	
Diwaniya	131.0	66.0	40.0	38.0	60.0	106.0	152.0	200.0	291.0	311.0	262.0	197.0	197.0	138.0	458.0	1061.0	1854.0	
Sinjar	117.0	62.6	22.6	27.0	38.5	60.2	116.2	195.3	265.6	288.6	277.0	197.0	179.6	88.1	371.7	1028.2	1667.6	Short series data mean used
Salahuddin	108.0	51.0	15.0	14.0	25.0	63.0	117.0	175.0	216.0	225.0	223.0	180.0	159.0	54.0	355.0	844.0	1412.0	
Nukhaib	144.0	58.0	40.0	43.0	72.0	140.0	185.0	223.0	336.0	369.0	298.0	240.0	202.0	155.0	548.0	1243.0	2148.0	

Source : UNESCO (1975) : Iraq : Contributions on Natural Resources Research, Paris, Table 11, p.57.

FIG. 11.14 MEAN ANNUAL POTENTIAL EVAPOTRANSPIRATION(cms)



Source : As in Fig 11.5, p.58.

water loss through potential evapotranspiration. For annual cereals a ground storage level of 100 mm. of moisture is taken as a significant indicator of an excess of rainfall over potential evapotranspiration.(24)

For working purposes the rainfall : P/E ratio can be categorised as follows:

1. Humid - the period when the rainfall is equal to or more than potential evapotranspiration.

2. Moist - when rainfall is equal to, or more than half of potential evapotranspiration.

3. Moderately dry to dry - when rainfall is less than half of potential evapotranspiration, but greater than one-tenth of it.

4. Very dry - when rainfall is equal to, or less than, one-tenth of potential evapotranspiration.

The application of this categorisation to the rainfed areas gives us the following division of the agricultural year :

1. During a moist period preceding the period of humidity (November) no irrigation is required as cereal crops at that time are in their initial growth stages and the actual evapotranspiration normally does not exceed 50 to 60 per cent of the potential evapotranspiration.

2. The humid period lasts from late November to April, although in the mountain region it lasts from early November to mid June. During the ripening stage the actual water demand starts falling off rapidly, and no irrigation is required. Accordingly, one may assume that water availability is sufficient, on average, for cereal crops in the rainfed area during the whole winter growing zone.

11.13 Relative Humidity: This is the last important meteorological factor of relevance here. Data based on actual recordings for 27 years are available for two stations (Mosul and Kirkuk) in the rainfed area. Tables 11.27 and 11.28 show the mean, minimum, maximum, standard deviation and the coefficient of variation of relative humidity for the two stations. Relative humidity increases gradually from October to January and it starts to decrease after that. In other words, relative humidity increasesas the amount of rainfall increases from October to January, whilst the coefficient of variation decreases as relative humidity increases. The coefficient of variation reaches its minimum level in January or February in the case of Mosul.

11.14 The growing Season: It is always difficult to establish a firm timetable for the growing season for cereal crops in the rainfed area. This depends, in general, on the relation between the rainfall season and the need for cultivation and/or sowing the land at the beginning of the season. If rainfall is delayed farmers postpone the time of sowing which will affect the phenological periods of the plant growth. UNESCO, however, has classified the growing season for wheat crops in Nineveh province as follows:-

1.	Seeding	1 - 20 November;
2.	Germination and tillering	Mid Nov. - End Feb.
3.	Heading	10 - 25 April;
4.	Ripening	25 May - 10 June;
5.	Period of active growth	1 March - 15 May;
		Duration 200 - 210 days

In general, the active growth period extends from the late humid period to the end of the moderate dry to dry period (1 March - 15 May). Planting occurs during the moist period (November), or in other words, takes place after a sufficient amount of rain has fallen.

Table 11.27 The Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Average Monthly Relative Humidity at Mosul Station in the Rainfed Area During the Growing Season

Month	No. of cases	Min.	Max.	Mean	St. Dev.	% of co-eff. of var.
October	27	19.00	44.00	29.82	6.31	21.16
November	27	38.00	70.00	51.89	8.80	16.96
December	27	51.00	78.00	67.52	7.20	10.66
January	27	46.00	88.00	70.04	8.48	12.11
February	27	54.00	75.00	65.00	6.10	9.38
March	27	45.00	71.00	58.52	7.66	13.09
April	27	31.00	67.00	51.22	8.35	16.30
May	27	22.00	60.00	34.93	10.25	29.34
Average season Rel.Humidity	27	55.10	73.40	66.22	4.22	6.37

Table 11.28 The Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Average Monthly Relative Humidity at Kirkuk Station in the Rainfed Area During the Growing Season

Month	No. of cases	Min.	Max.	Mean	St.Dev.	% of co-eff. of var.
October	27	37.00	61.00	48.78	6.35	13.02
November	27	51.00	78.00	67.04	6.88	10.26
December	27	69.00	89.00	79.70	5.14	6.45
January	27	68.00	85.00	80.44	3.98	4.95
February	27	61.00	85.00	74.44	5.44	7.31
March	27	54.00	81.00	69.48	6.83	9.83
April	27	35.00	77.00	62.82	9.19	14.63
May	27	25.00	70.00	47.04	10.29	21.88
Average season Rel.Humidity	27	47.00	59.20	53.63	3.62	6.57

Heading occurs during the periods ranging from moist to moderately dry and ripening during the moderate to dry period. So, it seems that rainfall distribution or water availability generally matches the phenological periods of the cereals growth in the rainfed area.

11.15 Conclusion and Final Remarks

The rainfed area of Northern Iraq has been chosen as a case-study of the effect of climate and weather on agricultural production and productivity. In this region agriculture is dominated by the cultivation of wheat and barley during the winter season and the direct impact of climatic factors, in particular rainfall, on production is not significantly modified by environmental control such as irrigation. The region produces approximately 60 per cent and 35 per cent respectively of the national wheat and barley production. About 66 and 38 per cent of the cultivated area under wheat and barley respectively lie in this region. Any impact of wheather conditions in general, and rainfall in particular, on the production of these two crops has serious consequences for the national economy.

Data required for this study are of two main types : agricultural and meteorological data. Agricultural data consist of measurements of production, cultivated area and yield of a particular crop. The selection of meteorological data is considerably governed by the availability of data relating to particular weather factors. In this case the three variables which can be utilised are : rainfall (monthly and annual), temperature (minimum and maximum) and relative humidity. Other climatic factors cannot be considered because time series records are too short and too few to enable useful analysis.

The production of wheat and barley fluctuated during the 27 years under the study (1949/50 - 1975/76). The coefficients of variation of wheat and barley production are 64.3 and 50.7 respectively. The coefficient of variation of area under wheat was 30.4 and under barley was 17.8. The coefficient of variation of production is higher than the coefficient of variation of area under production, thus other variables were involved, these variables ranging from technical and socio-economic to environmental. From the analyses made earlier in this thesis, it can be concluded that technical and socio-economic factors have had very little impact on production, and so the environmental conditions must be tested.

A series of regression analyses for area and production of wheat and barley shows that the area under wheat has increased at a higher rate than the rate of production growth, although there was no significant change either in the area under barley or in barley production. Another set of regression analyses for the yield of wheat and barley shows that there was no significant improvement in the yield of wheat. Barley shows a decline in the yield per land unit, although this decline is insignificant as a statistical trend.

We have seen that the rainfed area receives more rainfall than the rest of the country. About 88 per cent of the rainfall occurs in the rainfed area during winter and spring, compared with a national average of about 85 per cent. The monthly distribution shows that January is the wettest month for the whole country. In the rainfed area, March was the wettest month, this followed by February and January.

The study of variation in annual rainfall reveals that the coefficient of variation decreases as the annual rainfall increases.

The second meteorological variable, air temperature, is considered in the form of minimum, maximum and average mean temperature during the growing season. The feature critical to enable agriculture is the thermal threshold point, below which plant growth is very slow or ceases; this threshold in Iraq is taken as being $5^{o}C$. The number of occasions during the growing season when temperature falls for periods below this threshold may affect the plant growth in general and the yield in particular, and some risk does exist in parts of the rainfed area of Northern Iraq.

Soil temperature, although important for agroclimatological studies, cannot be incorporated in our analyses because of the absence of long time series data of this variable.

Agriculture in the rainfed area relies on water availability in the soil, this soil moisture balance is governed by the difference between water-supply and water-loss.

Analysing potential evapotranspiration reveals that the growing season starts with moist soil conditions in November during the sowing period. The humid period, from late November to April, is associated with active plant growth. During the ripening period soil water condition may be described as moderate dry to dry appropriate for plant needs. Thus the distribution of rainfall, the main determinant of water availability, coincides with plant requirements during the growing season, but variability both in total growing season rainfall and in distribution during the growing season can be critical.

Relative humidity increases during the growing season until it reaches its peak in January. This increase is related to the increase of rainfall. The coefficient of variation of the relative humidity decreases as the mean monthly relative humidity increases (See Tables 11.27 and 11.28).

We can state, therefore, that the phenological cycle of plant growth, within a growing season extending from October/November to May/June, matches the regime of water availability.

However, it can be concluded that the rainfall area, in general, is suitable for dry farming when the annual rainfall is at least 240 mm. and the coefficient of rainfall variation is no greater than 37.5 per cent, these as first approximations. In the following two chapters, we analyse the effect of rainfall, air temperature and relative humidity on wheat and barley in the rainfed area of Northern Iraq.

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CHAPTER TWELVE

THE EFFECTS OF WEATHER FACTORS ON WHEAT YIELD

12.1 Introduction

It became clear in the previous chapter that the rainfed area of northern Iraq is generally suitable for dry farming cereal production of wheat and barley. It was also concluded that no significant trend in wheat and barley yields could be demonstrated statistically (see Table 11.10), and consequently, fluctuations in the annual wheat and barley production during the period of study (1949/50-1975/76) are the resultants of two main factors : area and yield fluctuations. Yield fluctuations appears mainly due to variations in weather conditions both directly and indirectly. Although weather conditons may affect farmers' decisions determining the area cultivated, especially in the long term, this point will not be considered in this study (Fig.1.1). In this chapter, we shall concentrate on how much yield fluctuations were determined by climatic factors.

As earlier noted, the climate-crop relationship is complex, but now that this set of factors affecting agricultural productivity and production in Iraq has been as far as possible isolated from socio-economic and technical factors, we can turn to some simple direct statistical procedures for studying the effect of weather and climate on yields, first of wheat, and then of barley in Chapter 13, by using correlation and regression analyses.

Three main weather variables are used in both cases, rainfall (monthly and total), monthly temperature and relative humidity. As itwas noted earlier the lack of adequate data has prevented us from utilising other variables singly or in combination (see pages 426-427).

12.2 A Review of Other Relevant Studies

Whilst the study of the effects of weather conditions on agriculture is a very well developed subject in many countries (see chapter 10), as far as Iraq is concerned only two studies have been traced.

The first of these was published by UNESCO in 1976, in which three separate functions were arrived at[1] :

Y_e = $256.1 + 0.301\ X_1 + 0.937\ X_2$ for wheat

Y_e = $447.5 + 0.427\ X_1 + 0.935\ X_2$ for barley

Y_e = $950.3 + 0.209\ X_1 + 0.969\ X_2 + 44.9\ X_3$ for barley

Where :

Y_e = The estimated yield.

X_1 = The average rainfall for the north and north-east of Iraq for October-May.

X_2 = The average rainfall for the north and north-east of Iraq for January and April.

X_3 = The average temperature of November, January, March and April.

The above regression equations have multiple correlation coefficient of 0.65, 0.64 and 0.75 respectively, all of them significant at a 1 per cent level.

The second study was published by F.Y.Yussif in 1979.[2] He used regression analysis to study the effect of rainfall on the yield of wheat and barley in Nineveh and Sulaimaniya provinces in the rainfed area. Two sets of data were selected in this study, one based on the actual yields for these provinces between 1967/68-1975/76, the second set obtained from three experimental farms in these provinces. The final evaluation of the effect of rainfall and temperature were represented in 36 regression functions of wheat and barley.

He concluded that the relation between yield of the two crops and rainfall is positive in some cases and negative in others, implying that there are other factors affecting the yield other than rainfall. Yussif also concluded that there is a good possibility of improving yields through improving the farming system.

12.3 Analytical Approach

The total period under study here is between 1949/50 and 1975/76. During previous discussion of the socio-economic and technical factors, the need appeared for considering two sub-periods, i.e. the pre-land reform years between 1949/50 and 1957/58 and those of the post-land reform period between 1958/59 and 1975/76. Evidence already presented indicates the impact on agriculture of the institutional changes which followed land reform. In order to minimise the effects of these changes on this analysis it was decided to study the effect of weather on agriculture during four different periods :

I. The whole period between 1949/50 - 1975/76 (27 years);

II. Pre-land reform period between 1949/50 - 1957/58 (9 years);

III. Post-land reform period between 1963/64 - 1975/76 (13 years). Here, the first five years after land reform are excluded since these appear to have been years of agricultural adjustment, even dislocation, caused by land reform. During these five years the area under cultivation reached its lowest levels (see Appendix H, Table H.1 & H.3 for details).

IV. The fourth period is based on the combination of the two sub-periods 1949/50 - 1957/58 and 1963/64 - 1975/76 (22 years).

Correlation and regression analyses are used to study the effect of certain weather factors on cereal yields in the rainfed area of Northern Iraq. The statistical package programme used in this analysis is Midas (see reference 19).

12.4 The Correlation Between Wheat Yield And Total Rainfall

A series of correlation matrices have been carried out between annual rainfall and wheat yield for 22 selected meteorological stations in the rainfed area of Northern Iraq. Table 12.1 shows the coefficient of these correlations for the whole Period I (1949/50 - 1975/76). It is clear from this table that wheat yield is positively correlated with total rainfall in twelve stations. Although, these correlation coefficients are significant at 5 and 1 per cent level, they are not as high as reported in Jordan, Syria and Iran.[3,4] This does not mean that rainfall is necessarily less important in Iraq, but can be explained as follows. First, this could be due to the effect of rainfall distribution during the growing season, especially if the relatively mild winter which helps the plant growth, is taken into account.[5] Secondly, this 27 year period consists of two sub-periods which are known to have had different socio-economic conditions which could have affected the correlation between wheat yield and total rainfall.

One distinct fact of spatial differentiation to appear from these correlation coefficients is that the correlation between wheat yield and total rainfall is particularly low in the highland regions (over 600 m), with greater relief amplitude and where minor grain growing zones exist. (Fig.11.9 and Table 11.14 show the location and altitude of these stations). Nonetheless, there are some significantly positive correlation coefficients between wheat yield and total rainfall at high upland stations, for example Shaqlawa station in Arbil province, Sersank and Dohuk stations in Nineveh province and Chwarta station in Sulaimaniya province (although the latter station has a short 11 year time series). This suggests that other factors affect wheat yield in the upland stations in addition to rainfall, such as soil conditions, wind aspect and micro-climate conditions.

Al-Sherbini, however, argues that the correlation between wheat yield and total rainfall is relatively low when the total annual rainfall is relatively high, basing his conclusion on observations in Syria.[6] Hooker has similarly pointed out that when total rainfall is above a certain optimum level the correlation between a particular crop and rainfall is low because the relation itself is not linear.[7] He showed for example, that the correlation between oat yields and rainfall in eastern Scotland is low because the rainfall conditions are near the optimum level. Hooker's theory appears adequate to explain the low correlation between wheat yield and total rainfall in some high land stations of Northern Iraq where total rainfall is higher than in the foothill stations (see Table 11.14), but the question remains of how to determine the optimum level of rainfall! In agrometeorological terms one also has to consider rainfall distribution during the growing season, other climatic factors, as well as soil conditions and farming practice.

The correlation between wheat yield and total rainfall for the Period II between 1949/50 - 1957/58 (pre-land reform period) is very much higher than for the whole period. Table 12.2 shows the correlation coefficients between wheat yield and total rainfall which indicates that wheat yield was then clearly dominated by environmental conditions in general and rainfall in particular.

It appears, however, from Table 12.2 that the correlation between total rainfall and wheat yield is not always significant in the upland stations. Only three upland stations show a significant and positive correlation between wheat yield and total rainfall; Zakho, Dohuk and Amadiya in Nineveh province.

The third correlation series is carried out between total rainfall and wheat yield for Period III, post-land reform (1963/64 - 1975/76). Table 12.3 shows the results of these correlations. The coefficients of these correlations are very close to those obtained in Syria for the same period (1958 - 75).[8] It is obvious from this table that the correlation between wheat yield and total rainfall is generally lower than for the pre-land reform period, except for Telafar station which shows a very slight increase.

It is not easy to diagnose the reasons for the decrease in the correlation coefficient in this period in relation to the pre-land reform period, but it is probably due to a slight improvement of other non-climatic factors in general and to mechanization in particular. Chapter 8 shows that the number of tractors and combined harvestors increased during the whole period (see page 299). This suggests that some improvement in tillage, harvesting and timing of farm operations might have occurred in the post-land reform period. The mean of wheat yield in the post-land reform period was 141.7 kg./donum and the coefficient of variation was 45.3 per cent, compared with a mean of wheat yield for the pre-land reform period which was 123.48 with coefficient of variation of 48.8 per cent. This suggests that wheat yield became less affected by average annual rainfall, although severe drought or heavy rainstorms or a combination of adverse climatic factors could still be important. Nonetheless, Iraqi farmers in general are still not fully aware of the importance of dry farming, protecting against erosion, increasing moisture availability and improving productivity of the land.[9]

As far as the correlation between total rainfall and wheat yield according to altitude is concerned, Table 12.3 shows that rainfall is positively correlated at the foothill plains of the low relief amplitude where the major production zones exist.

The fourth series of correlations carried out between total rainfall and wheat yield is for Period IV, the two sub-periods between this 1949/50 - 1957/58 and 1963/64 - 1975/76 in combination. Table 12.4

shows the results of these correlations. This table shows that total rainfall is positively correlated with wheat yield both at 5 and 1 per cent level of significance in the foothill plains of low relief amplitude, such as Mosul, Sinjar, Telafar in Nineveh province and Kirkuk, Hawija, Iftikhar and Tuz-Khurmatu in Kirkuk province. In other stations the correlation is less significant as in the case of Aqra, Dohuk and Shaqlawa, or has no significant correlation. Rainfall in these latter stations is greater than stations in the foothill region. Zakho is an exception, but we have to set its significant correlation against the very small number of cases (short time series) (see Table 12.4).

Comparing the correlation coefficient of Period IV (22 year) with the others reveals the following points:-

1. The correlation coefficient of the 22-year Period IV (1949/50 - 1957/58 and 1963/64 - 1975/76) is generally improved in comparison to the 27-year Period I (1949/50 - 1975/76) (see Tables 12.1 and 12.4).

2. The correlation coefficients of the Period IV is lower than the correlation coefficients of the pre-land reform Period II (1949/50 - 1957/58), except for Sersank station which is located at a higher altitude. This supports the internal logic behind and other evidence leading to our sub-division of the whole period.

3. The correlation coefficients of the 22-year Period IV are generally higher than the correlation coefficients of the post-land reform period. Again, this reinforces the validity of our period sub-divisions.

It can further be concluded from these series of correlations between total rainfall and wheat yield :-

1. It seems that total rainfall is positively correlated with wheat yield in the foothills plains of low relief amplitude and where the major grain growing zones are located regardless of the selected period.

These stations are mainly located in Nineveh and Kirkuk provinces.

2. This does not mean that total rainfall in the uplands, where a greater amount of rainfall falls and where minor grain growing zones exist, is not important in relation to wheat yields.

3. It seems that the correlation between total rainfall and wheat yield is lowest when rainfall is highest.

4. The pre-land reform period was very much affected by physical environmental factors in general and total rainfall in particular (see Table 12.2). The highest rainfall correlation coefficient with wheat yield was obtained during this period.

5. The correlation coefficients for the post-land reform period between wheat yield and total rainfall were lower than for the pre-land reform period, and this suggests that, whilst in earlier sections of this thesis it appeared that socio-economic and technical benefits of post-1958 policy were on the whole disappointing, some associated improvements did lessen the adverse direct effects of climate on agriculture.

6. Excluding a five year period following the Land Reform Law of 1958 from the whole period results in improvement in all correlation coefficients. This implies that during these five years after 1958 there were various social, political and economic factors of adjustment and dislocation which affected production and productivity. The correlation coefficients for this selected Period IV generally lie between the correlation coefficients of the pre- and post-land reform periods. Period IV appears to be the most reliable for the study of the impact of weather factors on wheat yield.

12.5 The Correlation Between Wheat Yield and Monthly Rainfall

Here also a series of correlation matrices have been calculated between wheat yield and monthly rainfall for the four periods identified earlier in this chapter.

The correlation coefficients between wheat yield and October rainfall are negative but not significantly so in most stations for all periods as can be seen from Tables 12.1, 12.2, 12.3 and 12.4. This negative correlation between wheat yield and October rainfall is a matter of concern and requires some explanation. First, sudden heavy showers may delay soil preparation and encourage farmers to postpone cultivation and sowing. Consequently this may shorten the growing season and lead to a lower final yield. Oury found in France that, similarly, autumn rain tends to delay or hamper soil preparation for and sowing of winter wheat.(10) Secondly, October rainfall can be observed to increase weed growth in fields, and consequently, this may reduce yields. Khammo's observations of weeds in wheat in Sulaimaniya province is relevant here.(11) A study in India reveals that additional rainfall during the tilling phase is detrimental to wheat yield.(12) The firm causative links cannot be found without proper field studies including micro-climate investigation, and such studies are beyond this thesis. Bearing in mind, however, both October temperature (see Tables 11.22 and 11.23) and October rainfall (see Table 11.16), we can assume that the second factor, weed growth, is one important explanation for this negative correlation between wheat yield and October rainfall.

November rainfall clearly has an important role in determining final wheat yield. The correlation between wheat yield and November rainfall for the whole period (27 year) is significantly positive at six stations (see Table 12.1). These stations are Mosul, Sersank and Dohuk in Nineveh province, Shaqlawa in Arbil province and Bakrajo and Chwarta in Sulaimaniya province. Only Arbil station shows an insignificant negative correlation. For the rest of the stations, the correlation of November rainfall with wheat yield is generally higher than October, but not statistically significant.

For the pre-land reform period (9 years), the correlation between wheat yield and November rainfall is not significant, except in three upland stations (see Table 12.2). These stations are Halabja, Penjwin and Chwarta. Telafar, Iftikher and Arbil Stations show negative correlation coefficients but they are not significant. Other stations show insignificant positive correlation.

For the post-land reform period (13 years), the correlation between wheat yield and November rainfall is positively significant in Dohuk, Iftikhar and Shaqlawa stations (see Table 12.3). Three stations have insignificant negative correlations. These stations are Amadiya and Zakho in Nineveh province and Tuz-Khurmatu in Kirkuk province. Other stations show insignificant positive correlation between wheat yield and November rainfall. These correlation coefficients, however, are higher than the October correlation coefficients in general. These and the preceding results tend to weaken the argument that pre-land reform agriculture was more vulnerable to weather forces than the post-reform period.

In the case of the 22 year period, the correlation coefficients between wheat yield and November rainfall are very close to the correlation coefficients of the whole period in general. As can be seen from Table 12.4 the correlation coefficients are positively significant at seven stations. These stations are Mosul and Dohuk in Nineveh province, Shaqlawa in Arbil and finally Halabja, Bakrajo, Penjwin and Chwarta in Sulaimaniya province. Two stations have insignificant negative correlation coefficients. These stations are Hawija and Arbil. The rest of the stations have insignificant positive correlation coefficients.

Generally speaking since germination and tillage occur from late November to December, November rainfall tends to be very crucial in providing sufficient soil moisture for seeds to germinate.

Considering, in general, the correlation between wheat yield and December, January and February rainfall for the whole period reveals that those three months have less impact on final yield. None of the correlation coefficients are significant, except for December and February rainfall at Telafar station and December rainfall in Sinjar are significant at 5 per cent level (see Table 12.1).

It seems, however, that in the upland region where small grain growing zones exist, December, January and(February at two stations) have insignificant negative correlation. This means that any increase in the rainfall during these months might reduce the final yield. Other upland stations mainly in Arbil and Nineveh provinces, however, do not share these characteristics. The probable reason for this negative correlation is that December and January in particular, together with February are the coldest months during the growing season (see Tables 11.22 and 11.23). During this period plant growth can be either very slow or nil, and less water is required. In addition, low temperatures during these three months also reduce the amount of evaporation and consequently leave enough soil moisture for what plant growth occurs.

In the case of the pre-land reform period, December and January rainfall show a mixture of insignificant negative and positive correlations with wheat yield, except for Aqra and Telafar stations where both of them are significantly and positively correlated (See Table 12.2). February, on the other hand, shows a significant correlation in Iftikhar and Tuz-Khurmatu (see Table 12.2). There is no significant correlation between wheat yield and February rainfall in other stations.

For the post-land reform period, the correlation coefficients between wheat yield and December and January rainfall are insignificant, as can be seen from Table 12.3. Only Sinjar station shows a significantly positive correlation between December rainfall and wheat yield. The correlation between wheat yield and February rainfall is only significantly positive in Telafar and Zakho stations, while it is significantly negative in Amadiya (see Table 12.3). The correlation coefficients in other stations are not significant.

In the case of the 22 year Period IV, Table 12.4 shows that the correlation between December, January and February rainfall and wheat yield is not significant except in Telafar station where February rainfall is positively significant.

As mentioned before, most active plant growth extends from March to April (see p.457), and consequently one would expect more positive correlation between rainfall during these months and wheat yield.

Examining the correlation between wheat yield and March and April rainfall for the whole period reveals that rainfall in these two months might have a significant impact on the final yield. In fact, March and April rainfall are significantly correlated with yield in most of the foothill stations, while it is less significant in the upland stations (see Table 12.1). This could be explained by two factors. First, the upland stations receive more rainfall than the foothill region and one would assume that more soil moisture was available for plants during March and April. Secondly, evaporation is lower in the upland stations because of relatively low temperatures and this probably means more adequate available soil moisture. The lack of more detailed data, especially for soil moisture, prevented us from drawing more precise conclusions. Only two upland stations show insignificant negative correlation between April rainfall and wheat yield : Amadiya in Nineveh province and Salahuddin in Arbil province. For other stations, the correlation coefficients are insignificantly positive although higher than the correlation coefficient of January and February in general. This implies that April and March rainfall may still have some impact on the final yield.

As for the pre-land reform period, the correlation between wheat yield and March and April rainfall is significantly positive in most of the foothill stations (see Table 12.2). Only Salahuddin station in Arbil province shows insignificant negative correlation between wheat yield and April rainfall. The rest of the stations show insignificant positive correlation coefficients, and these coefficients are higher than January and February correlation coefficients.

The post-land reform period shows a difference in correlations between March and April rainfall and wheat yield as can be seen from Table 12.3. March rainfall is nowhere significantly correlated, negatively or positively, with yield. April rainfall, on the other hand, is significantly correlated with wheat yield only in Sinjar and Mosul stations. It is clear that the relationship between wheat yield and March and April rainfall in Period III (post-land reform) differs from the relation between wheat yield and March and April rainfall in Periods I and II. This difference appears to be due to a combination of four factors:-

1. In Period III, the average mean of March and April rainfall is generally higher than for the whole Period I.

2. The coefficient of rainfall variation for each month tends to be high at the beginning of the rainy season (October and November) and becomes lower in December, January and February, increasing again during March, April and May as the end of the rainy season approaches.

3. The coefficient of rainfall variation for each month for the short period tends to be higher, indicating that rainfall is more changeable in the shorter period than in the longer one.

4. In the post-land reform period, as noted earlier, we are dealing with a situation in which physical environmental conditions according to other evidence are less dominant.

The correlation between wheat yield and March and April rainfall for the 22 year Period IV has improved slightly in relation to the whole period correlation coefficients. For Period IV March and April rainfall is significantly correlated in most of the foothill stations, as can be seen from Table 12.4. For the upland stations, the correlation is not significant, except in Chwarta, but the record for this station is very limited. Generally speaking this low correlation between wheat yield and March and April rainfall is due to the reasons given on page 475. Salahuddin station shows an insignificant negative correlation between wheat yield and April rainfall. At other stations, the correlation coefficients are insignificantly positive.

The last month of the growing season for cereals is May; from mid May the wheat crop can be ready for harvesting in some years and in some locations. Insufficient detailed data is available to show how large a proportion of the main harvest period, which on average falls in June, does actually take place in that month. So, for example, in one year in Kirkuk province over 95 per cent of the wheat harvest may take place in June, whilst in Sulaimaniya province it may be 80 per cent. In the following year there may be no change in Kirkuk province but the proportion in Sulaimaniya province may fall to 50 per cent. Many factors could be involved in determining this type of seasonal and regional variation for example, the date of sowing can vary according to climatic and other factors as noted earlier; the seasonal temperature regime and rainfall distribution during the growing season can have significant influences; soil texture and fertility with their regional variation will also have an effect.

Given all this the correlation between May rainfall and wheat yield could be expected to be complex or even confused. An examination of the correlation between wheat yield and May rainfall for Periods I to IV as shown in Tables 12.1 to 12.4 does in fact show the following:-

a). In all four periods there are more positive correlation coefficients than negative.

b) In Period II, for which, as noted elsewhere, there is some evidence that climatic influences on production were stronger than during Period III, 8 out of 22 stations record negative correlation coefficients compared with 2 out of 22 in Period III. However, except for five positive correlation coefficients at four stations in Kirkuk province and Salahuddin station in Arbil province, all other correlation coefficients, both positive and negative, are very low.

c) In Period III there are eight significantly positive correlation coefficients and both negative correlation coefficients are weak. Perhaps of importance, is the fact that of the significant positive correlations, 3 are again in Arbil province, 2 in Kirkuk province and three now appear in Nineveh province.

d) When we examine the larger selected time series in Periods I and IV, the overall balance is one of positive correlation coefficients compared with Period I. The effect of selecting the 22-year period (Period IV), here as elsewhere is one of strengthening the correlation coefficients. Significantly, the strongest correlation coefficients are found at all the four stations in Kirkuk province, Salahuddin in Arbil province and Aqra in Nineveh province.

The only tentative conclusions we can establish are that May rainfall at some places and in some years can be slightly counter-productive, for example, if it coincides with the harvesting of ripened grain or if it comes as damagingly heavy showers. On the other hand, in some regions, possibly in Kirkuk province, May rainfall may predominantly fall at a not too late stage of grain ripening and thus be beneficial. We may also note (see Appendix H, Table H.7) that the coefficient of variation of May rainfall is second only to that of October and much higher than that of intervening months. From this statistical analysis and our observation of other farming variables, both in time and place, we can only say that the effect of May rainfall on wheat production and productivity cannot be exactly stated in general terms applicable to the whole rainfed zone.

One can sum up from the foregoing discussion the following main points:-

1. October rainfall is negatively correlated with wheat yield in all periods. Although these correlations coefficients are not significant from the statistical point of view, they are still a matter of concern. Two reasons have been proposed for these negative correlations : weed growth and delaying the sowing time. But in fact, without a field study this negative relation cannot completely be explained.

2. November rainfall (early rainfall) is very important due to the fact that its occurrence coincides with the germination period.

3. December, January and February rainfall are not significantly correlated with wheat yield, except at one or two stations and some stations in the uplands as well as in the foothills have insignificant negative correlation coefficients. The reason for this appear to be that active plant growth is at its lowest and least responsive to rainfall.

Table 12.1 The Correlation Between Monthly Rainfall, Total Rainfall and Wheat Yield in the Rainfed Area (1949/50-1975/76), I

Station	No. of cases	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Total Rain-fall
Nineveh										
Sinjar	27	.081	.360	.391*	.284	.136	.232	.521**	-.113	.489**
Mosul	27	.018	.429*	.227	.154	.177	.393*	.402*	-.232	.477*
Telafar	27	.068	.220	.429*	.249	.407*	.381*	.260	-.054	.624**
Aqra	20	-.140	.394	.290	.351	.012	.300	.158	.188	.403
Sersank	20	-.200	.491*	.083	.361	.342	.481*	.365	-.106	.461*
Dohuk	20	-.059	.584**	.199	.238	.123	.248	.357	.148	.528*
Amadiya	18	-.255	.326	-.066	.001	-.164	.236	-.021	.152	.048
Zakho	13	.224	.241	.233	.033	.376	.576*	.346	.154	.681*
Kirkuk										
Kirkuk	27	-.376	.180	.038	.183	.142	.369	.418*	.111	.555**
Hawija	27	-.383	.030	.190	.189	.033	.653**	.458*	.141	.644**
Iftikhar	21	-.405	.424	-.034	.118	.290	.565**	.648**	.086	.738**
Tuz-Khurm-atu	21	-.128	.160	-.076	.161	.219	.533*	.485*	-.059	.466*
Arbil										
Shaqlawa	27	-.167	.502**	.269	.043	.339	.098	.082	.285	.395*
Arbil	23	-.353	-.028	.009	.176	.206	.210	.122	.193	.298
Rawanduz	22	-.073	.419	.383	.110	.089	.132	.003	.032	.338
Salahuddin	21	-.021	.171	.094	.206	.022	.176	-.243	.196	.194
Sulaimaniya										
Dokan	26	-.158	.247	.029	-.064	.118	.199	.175	-.185	.160
Sulaimaniya	23	-.175	.370	-.219	-.348	.172	.204	.121	-.405	.029
Halabja	19	.092	.324	-.153	-.167	.135	.235	.099	-.343	.061
Bakrajo	20	-.148	.454*	-.143	-.186	-.044	.165	.192	.271	.046
Penjwin	12	-.030	.693	-.453	.037	.013	.322	.381	-.140	.336
Chwarta	11	.228	.771*	-.282	-.120	.501	.278	.615*	-.244	.622*

* Significant at 5% level.
** " 1% "

Table 12.2 The Correlation Between Monthly Rainfall, Total Rainfall and Wheat Yield in the Rainfed Area (1949/50-1957/58), II

Station	No.of cases	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Total Rain-fall
Nineveh										
Sinjar	9	.505	.226	.109	.378	.239	.742*	.757*	.190	.766*
Mosul	9	.075	.366	.345	-.028	.293	.788*	.571	.085	.745*
Telafar	9	.208	-.074	.164	.873**	.104	.825**	.463	-.256	.787*
Aqra	6	.150	.696	.851*	.955**	.085	.714	.394	.247	.748
Sersank	7	-.179	.463	-.252	.125	.272	.419	.443	.020	.326
Dohuk	8	.093	.546	.004	.390	.310	.807*	.304	-.200	.780*
Amadiya	8	-.169	.586	-.481	.423	.421	.681	.591	-.098	.888**
Zakho	7	.064	.493	.000	-.172	.587	.850*	.537	.142	.778*
Kirkuk										
Kirkuk	9	-.117	.066	-.159	-.225	.477	.890**	.708*	.541	.815**
Hawija	9	-.511	.363	-.126	-.007	.293	.933**	.758*	.472	.862**
Iftikhar	9	-.296	-.162	-.266	.016	.743*	.779*	.819**	.569	.862**
Tuz-Khur-matu	7	-.386	.189	-.367	-.170	.756*	.879**	.885**	.561	.892**
Arbil										
Shaqlawa	9	.040	.454	-.160	-.034	.330	.497	.279	.063	.389
Arbil	9	-.280	-.250	-.233	.082	.244	.628	.459	.032	.326
Rawanduz	9	.078	.360	.418	.181	.057	.462	.341	.038	.486
Salahuddin	4	-.064	.115	.027	.288	.219	.882	-.085	.587	.936
Sulaimaniya										
Dokan	8	-.394	.253	-.054	-.225	.254	.369	.548	-.070	.285
Sulaimaniya	8	-.252	.694	-.307	-.480	.411	.285	.559	.040	.319
Halabja	9	.688*	.748*	-.282	-.156	.325	.352	.606	-.070	.548
Bekrajo	6	-.342	.653	-.493	-.328	.246	.477	.440	-.121	.287
Penjwin	9	-.088	.719*	-.625	-.023	.048	.382	.456	-.200	.377
Chwarta	7	.367	.878**	-.414	-.266	.564	.410	.780*	-.198	.666

* Significant at 5% level.

** " 1% "

Table 12.3 The Correlation Between Monthly Rainfall, Total Rainfall and Wheat Yield in the Rainfed Area (1963/64-1975/76), III

Station	No.of cases	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Total Rain-fall
Nineveh										
Sinjar	13	-.088	.278	.550*	.223	.211	.066	.682**	.092	.542*
Mosul	13	-.109	.447	.234	.106	.020	.428	.523*	-.044	.572*
Telafar	13	-.064	.228	.509	.237	.666*	.201	.399	.766**	.792**
Aqra	13	-.305	.458	.250	.107	.058	.097	.273	.748**	.409
Sersank	7	-.350	.398	.645	.670	.590	.517	.010	.694	.622
Dohuk	7	-.226	.761*	.501	.090	-.653	.232	.471	-.108	.485
Amadiya	8	.813	-.344	-.164	-.211	-.779*	-.012	-.261	.548	-.259
Zakho	6	.155	-.282	.201	.047	.841*	.573	.063	.857*	.550
Kirkuk										
Kirkuk	13	-.576*	.107	.149	.235	.066	.136	.342	.664*	.524
Hawija	13	-.615*	.083	.361	.179	-.784	.527	.466	.774**	.722**
Iftikhar	7	-.784*	.849*	-.463	-.248	-.229	.161	.706	.248	.538
Tuz-Khur-matu	10	-.129	-.029	.029	.114	.063	.461	.134	.318	.278
Arbil										
Shaqlawa	13	-.428	.664*	.473	.428	.385	-.060	.004	.705**	.571*
Arbil	13	-.432	.143	.225	.250	.247	.024	-.015	.498	.335
Rawanduz	8	-.153	.411	.648	.615	.071	-.535	.353	.736*	.487
Salahuddin	12	-.156	.419	-.151	.229	.030	-.037	-.424	.727**	.014
Sulaimaniya										
Dokan	13	-.287	.255	.086	-.027	.278	-.138	.095	.529	.252
Sulaimaniya	10	-.433	.062	-.378	-.177	.412	.368	-.118	.037	.125
Halabja	5	.379	.334	-.281	.583	.037	.863	.262	.403	.595
Bekrajo	9	-.361	.290	-.860	.164	-.172	-.120	-.019	.652	.095
Penjwin +										
Chwarta +										

* Significant at 5% level

** " 1% "

\+ No Correlations because there are few cases.

Table 12.4 The Correlation Between Monthly Rainfall, Total Rainfall and Wheat Yield in the Rainfed Area (1949/50-57/58,1963/64-75/76), IV

Station	No.of cases	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Total Rain-fall
Nineveh										
Sinjar	22	.065	.265	.379	.259	.176	.296**	.708**	.113	.599**
Mosul	22	-.016	.436*	.240	.062	.119	.536**	.532**	.015	.613**
Telafar	22	.030	.182	.418	.227	.463*	.469*	.434*	.333	.776**
Aqra	19	-.191	.368	.340	.431	.047	.275	.271	.632**	.512*
Sersank	16	-.226	.462	.053	.324	.282	.479	.315	.070	.437
Dohuk	15	-.093	.531*	.221	.237	.068	.314	.356	-.159	.541*
Amadiya	16	-.072	.313	-.086	.079	-.161	.235	.104	.118	.109
Zakho	13	.224	.241	.233	.033	.376	.576*	.346	.154	.681**
Kirkuk										
Kirkuk	22	-.407	.097	-.008	.094	.205	.416	.486*	.554**	.656**
Hawija	22	-.505	-.014	.199	.137	.071	.719**	.554**	.444*	.783**
Iftikhar	16	-.476	.281	-.122	-.113	.380	.661**	.764**	.509*	.796**
Tuz-Khurm-atu	17	-.096	.065	-.122	.010	.380	.646**	.465	.413	.550*
Arbil										
Shaqlawa	22	-.277	.527*	.260	.188	.353	.124	.094	.368	.451*
Arbil	22	-.353	-.014	-.001	.158	.247	.214	.114	.194	.296
Rawanduz	17	-.037	.373	.443	.319	.053	.128	.318	.203	.474
Salahuddin	16	-.087	.320	-.091	.247	.085	.265	-.282	.518*	.235
Sulaimaniya										
Dokan	21	-.269	.250	.033	-.155	.237	.193	.263	.223	.269
Sulaimaniya	18	-.293	.499	-.328	-.359	.399	.293	.180	.037	.222
Halabja	14	.094	.545*	-.220	-.078	.265	.334	.524	.033	.390
Bakrajo	15	-.342	.550*	-.203	-.145	.161	.282	.238	.067	.231
Penjwin	9	-.088	.719*	-.625	-.023	.048	.382	.456	-.120	.377
Chwarta	7	.367	.878**	-.414	-.266	.564	.410	.780*	-.198	.666

* Significant at 5% level.
** " 1% "

4. March and April rainfall is significantly correlated in most of the foothill stations with wheat yield. The post-land reform period shows a different form of correlation between wheat yield and March and April rainfall than does the pre-land reform period. This changing pattern of correlations in this short period is attributable not only to climatic factors but also to socio-economic and technological. Within the climatic factors it appears that rainfall is statistically more changeable during the short periods especially for these months at the beginning or end of the rainy seasons.

5. May rainfall shows both negative and positive correlation coefficients. The reasons for that can be explained by two factors; first the form and time of rainfall occurrence, and secondly, the stage of plant growth at the time that rainfall is received. Again for the short period following land reform the difference between correlation coefficients before and after land reform indicates the presence of other causal factors (see p.471).

12.6 The Correlation Between Wheat Yield and Air Temperature

The influence of temperature on yield of a particular crop comes directly through the development of the plant, and indirectly through the influence of temperature on water availability and water stress.[13] It was noted in Chapter 11 data on temperature is only available for two stations in the rainfall area of Northern Iraq : Mosul and Kirkuk, both located in the foothill region where major cereal zones exist. The series of correlations analysed are between wheat yield and first, average monthly maximum temperature; second, average monthly minimum temperature; third, the average monthly mean temperature and fourth the average seasonal minimum, maximum and mean temperatures.

12.6.1 The Correlation Between Wheat Yield And Average Monthly Maximum Temperatures

The analysis of correlation between wheat yield and average monthly maximum temperature is based, as before, on four periods (see page 466). Table 12.5 shows the results of these correlations. One of the most obvious points to emerge is that the average monthly maximum temperature is negatively correlated with wheat yield, except for October which has a positive correlation. This implies that maximum temperature has negative effects on the field yield. This seems logical in an arid region where high temperatures mean high radiation and high evaporation, especially at the beginning and at the end of the growing season of cereals.

Considering the significance of these correlations for both stations for all periods reveals that average November and December maximum temperatures are significantly and negatively correlated with wheat yield (see Table 12.5). This is, one might expect, taking into account the average mean monthly rainfall in these two months (see Table 11.16) and the average mean monthly maximum temperature (see Tables 11.20 and 11.21). This means any decline in the average monthly maximum temperature will reduce the amount of evaporation and consequently will increase soil moisture. Improving soil moisture during the germination period is an important factor affecting yield.

In the case of average January maximum temperature it is not significantly correlated with wheat yield at the Kirkuk station for any of the four periods, but is significantly and negatively correlated for the two subperiods I and IV, at Mosul station (see Table 12.5). However, all the January correlation coefficients are lower than the correlation coefficients for November and December. Average February maximum temperature is not significantly correlated with wheat yield for any period at either station. We can suggest the following reasons for this low correlation between yield and average January and February maximum temperatures. First, average

January and February maximum temperatures are lower than recorded for other months of the growing season (see Table 11.20 and 11.21) and, other things being equal, evaporation will be less than in November and December (see Table 11.25). Secondly, the amount of rainfall is relatively high (see Table 11.16) so that even when evaporation occurs there is sufficient soil moisture to support the low level of plant growth at this time. Average March maximum temperature is only significantly and negatively correlated with wheat yields at Mosul station in the 22 year Period IV. Average April maximum temperature is significantly and negatively correlated with wheat yield in Kirkuk station in the pre-land reform Period II. Average May maximum temperature is significantly and negatively correlated with wheat yield in Kirkuk in the post-land reform Period III. The reason for this variety of correlations between March and May appear as follows : the direct effects of seasonal changes in average monthly maximum temperatures do not appear to be critically important for cereal crops which have been chosen for their general suitability for the prevailing thermal regime. The indirect effects of changes in average monthly maximum temperatures, e.g. through influencing evaporation rates, do not appear to be large enough to affect plant growth during the wettest months, December to February, or reduce soil moisture significantly between March and May when there is some rainfall. The high variability of rainfall between March and May and the correlation between this and yields seem to be sufficiently strong to make the correlation between average monthly maximum temperature and wheat yield rather weakly variable.

12.6.2 The Correlation Between Wheat Yield and Average monthly Minimum Temperature

Four sets of correlations have been calculated for Mosul and Kirkuk stations and are shown in Table 12.6. In general, average monthly minimum temperature is less important than the average monthly maximum temperature.

Table 12.5 The Correlation Between Maximum Temperature and Wheat Yield at Mosul and Kirkuk Stations

Month	Kirkuk				Mosul			
	Number of Cases				Number of Cases			
	27 I	9 II	13 III	22 IV	27 I	9 II	13 III	22 IV
October	.051	.188	.027	.091	-.021	-.057	.074	-.022
November	-.507**	-.398	-.576*	-.483*	-.522**	-.685*	-.399	-.484*
December	-.408*	-.401	-.480	-.445*	-.610**	-.649	-.674*	-.660**
January	-.275	-.367	-.099	-.208	-.471*	-.320	-.499	-.430*
February	-.290	-.262	-.330	-.305	-.234	-.361	-.245	-.314
March	-.193	-.258	-.420	-.311	-.133	-.542	-.472	-.453*
April	-.236	-.856**	-.127	-.251	-.196	-.406	.078	-.217
May	-.153	-.201	-.675*	-.292	-.080	-.422	-.146	-.247
Av.Seasonal Maximum Temperature	-.559**	-.673*	-.594*	-.626**	-.596**	-.795**	-.667*	-.703*

* Significant at 5% level.
** " 1% "

Average monthly minimum temperature tends to be negatively correlated with wheat yield between October to February. Average March and April minimum temperature tends to be positively correlated with wheat yield, except for a few cases. Average May minimum temperature is negatively correlated with wheat yield.

In terms of significance, average November minimum temperature is significantly and negatively correlated with wheat yield at both stations in the pre-land reform Period II. Average December minimum temperature is significantly and negatively correlated with wheat yield in three periods in Kirkuk but not at Mosul. Average February minimum temperature is significantly and negatively correlated with wheat yield in Mosul station in the post land reform Period III. Some general conclusions can be drawn.

1. Average November and December minimum temperatures are as important as average monthly maximum temperatures because whilst temperatures drop during the night thus saving evaporation of soil moisture, minimum temperatures do not appear to inhibit germination.

2. Average January and February minimum temperatures have little influence on the yield even though average monthly minimum temperatures drop below the theoretical threshold point (see p.444). Wheat can withstand low temperatures and tolerate a relatively wide range of temperature at this state of growth.[14,15] Moreover, the meteorological station records refer to air temperatures and since soil temperature at 10 cm. at 6 a.m. is above freezing point (see Table 11.24) we have to conclude that low average monthly minimum air temperatures are not in general critical for yields over periods of 10 years or more.

Nonetheless, this does not mean that wheat yield is unaffected by frost damage in some exceptional cold winters. The positive correlation between wheat yield and average April and March minimum temperature

Table 12.6 The Correlation Between Minimum Temperature and Wheat Yield at Mosul and Kirkuk Stations

Month	Kirkuk				Mosul			
	Number of Cases				Number of Cases			
	27 I	9 II	13 III	22 IV	27 I	9 II	13 III	22 IV
October	-.047	.140	-.196	-.027	-.192	-.358	-.343	-.202
November	-.361	-.730*	-.193	-.350	-.044	-.667*	.022	-.130
December	-.482*	-.690*	-.342	-.488*	-.150	-.480	-.131	-.225
January	-.300	-.392	-.138	-.231	-.141	-.133	-.104	-.104
February	-.262	.072	-.466	-.244	-.076	.245	-.573*	-.165
March	.075	.179	-.133	.029	.164	.127	.038	.132
April	.028	-.636	.294	.091	.049	-.330	.190	.138
May	-.104	-.400	-.144	-.237	-.254	-.547	-.471	-.277
Av.Seasonal Minimum Temperature	-.399*	-.526	-.336	-.386	-.183	.687*	-.368	-.228

* Significant at 5% level.

** " 1% "

probably means that minimum temperature does affect the plant itself during a critical period of phenological growth, for example, flowering, seed forming, etc. Moreover, there are negative though statistically insignificant correlations between wheat yield and average October and May minimum temperatures.

12.6.3 The Correlation Between Wheat Yield and Average Monthly Mean Temperature

The average monthly mean temperature utilised here is simply the minimum plus the maximum temperatures divided by 2, since the latter are the only available published data.

A series of correlations between wheat yield and the average monthly mean temperature has been calculated. The results of these correlations are shown in Table 12.7 and from these certain observations can be made.

1. The average monthly mean temperature is negatively correlated in most cases.

2. Average monthly mean temperature is most important at early stages of plant growth, November and December, because of the relation between temperature and the amount of rainfall during this period and the consequent effects on soil moisture balance. Table 12.7 shows that average November and December mean temperatures are significantly and negatively correlated with wheat yield in many cases.

3. Average January, February and March mean temperatres have no significant influence on wheat yields for the same reasons mentioned earlier (p.485).

4. Average April mean temperature is negatively and significantly correlated at 1 per cent level in Kirkuk station in the pre-land reform period.

Table 12.7 The Correlation Between Average Monthly Mean Temperature and Wheat Yield at Mosul and Kirkuk Stations

Month	Kirkuk				Mosul			
	Number of Cases				Number of Cases			
	27 I	9 II	13 III	22 IV	27 I	9 II	13 III	22 IV
October	.004	.214	-.086	.039	-.142	-.226	-.169	-.142
November	-.479*	-.588	-.435	-.465*	-.386*	-.896**	-.257	-.387
December	-.456*	-.541	-.424	-.477*	-.489**	-.651*	-.487	-.548**
January	-.310	-.391	-.132	-.240	-.371	-.267	-.376	-.332
February	-.286	-.121	-.415	-.295	-.159	-.058	-.410	-.254
March	-.076	-.068	-.311	-.162	-.075	-.348	-.248	-.213
April	-.141	-.816**	.197	-.131	-.111	-.263	.042	-.094
May	-.143	-.263	-.468	-.296	-.200	-.582	-.322	-.368
Average Seasonal Mean Temperature	-.511**	-.598	-.511	-.538**	-.511**	-.745*	-.578*	-.597**

* Significant at 5% level.

** " 1% "

5. Average October and May mean temperatures are not significantly correlated with wheat yield.

12.6.4 The Correlation Between Wheat Yield and Seasonal Temperature

Three average seasonal temperatures have been calculated. These averages are : first, average seasonal maximum temperature; second, average seasonal minimum temperature and third, average seasonal mean temperatures.

The correlations between wheat yield and the average seasonal maximum temperature are significantly negative in all periods in both stations (see Table 12.5). In fact, the correlation coefficients between wheat yield and average seasonal maximum temperatures are more significant than the correlation of indiviual months.

The correlation between wheat yield and average seasonal minimum temperature is less significant. The correlation coefficients are significant in two periods only (see Table 12.6). The correlation between wheat yield and average mean seasonal temperature is significantly negative in most periods except two, as can be seen from Table 12.7.

The general conclusions which can be drawn from the foregoing analysis of the correlation between wheat yield and temperature are as follows:-

1. Average monthly maximum temperature is most important at the beginning of the growing season. This is related to high temperatures leading to high evaporation rates and consequently water stress at germination. Average monthly rainfall does not appear high enough to counteract this drying out and any drop in maximum temperature seems to help to conserve soil moisture. Statistically this is proved by a very significant negative correlation between monthly rainfall and average monthly maximum temperature, especially in October and November.

2. Average monthly minimum temperatures have less influence on wheat yield in general, but are also most important at the beginning of the growing season. To some extent there may be a direct occasional negative effect of very low minimum temperatures on plant growth, but indirectly monthly minimum temperatures do not affect soil moisture in the same degree as the maximum temperature. The latter point is reinforced by the low correlation between minimum temperature and rainfall.

3. The average seasonal maximum temperature and the average mean seasonal temperature appear to be better indications of final yield than does average seasonal minimum temperature.

12.7 The Correlation Between Wheat Yield and Relative Humidity

Four series of correlations between wheat yield and relative humidity for each station have been analysed and the results shown in Table 12.8. It is clear that late season relative humidity is more important in determining the final yield. Relative humidity during March, April and May to some extent affects plant absorption of water during this active growth period and can affect seed formation.

March relative humidity is significantly and positively correlated in Mosul and Kirkuk stations in the pre-land reform Period II. April relative humidity, on the other hand, is not significantly correlated at either station in the post land reform Period III. May relative humidity is significantly and positively correlated with wheat yield in two Periods III and IV in both stations (see Table 12.8).

As for other months, the correlation coefficients are not significant regardless of the sign of the correlation, except October which shows a significant negative correlation in Kirkuk in one period.

Table 12.8 The Correlation Between Relative Humidity and Wheat Yield at Mosul and Kirkuk Stations

Month	Kirkuk				Mosul			
	Number of Cases				Number of Cases			
	27 I	9 II	13 III	22 IV	27 I	9 II	13 III	22 IV
October	-.383*	-.385	-.468	-.422	-.181	-.076	-.324	-.289
November	.234	-.266	.441	.133	.268	.109	.294	.169
December	.103	-.405	.348	.057	.055	-.070	.154	.052
January	.029	-.507	.215	-.037	.256	.105	.314	.182
February	-.089	.192	-.456	-.183	.089	.471	-.114	.050
March	.244	.682*	.155	.310	.274	.826**	.285	.373
April	.517**	.852**	.358	.589*	.451*	.744*	.436	.524*
May	.312	.549	.755**	.612*	.287	.487	.670*	.510*

* Significant at 5% level
** " 1% "

12.8 Regression Analysis

This is the second procedure used to analyse the effect of rainfall, temperature and relative humidity on wheat yield in the rainfed area of northern Iraq. After testing several mathematical techniques it was decided to apply linear and multi-linear regression functions.[16,17,18] In the case of multi-linear equations, the selection of the independent variables in the equation is achieved by using a stepwise regression technique.[19]

12.9 The Effect of Total Annual Rainfall on Wheat Yield

Regression analysis is first used to study the effect of total annual rainfall on wheat yield for each province in the rainfall area.

12.9.1 The Effect of Total Rainfall on Wheat Yield in Nineveh Province

Eight meteorological stations in Nineveh province are selected for a regression of average wheat yield against total rainfall at each station in the province. Bearing in mind the significance of the correlation coefficients between wheat yield and total rainfall found in Section 12.4, one may anticipate that the foothill stations will give more reliable results. That this is so, with the best results obtained at Telafar station, can be seen in Table 12.9 for all periods. Other results can be seen in Appendix I, Table I.1.

The first function in Table 12.9 explains 39 per cent of the annual wheat yield variation for the whole period in this province. The standard error of this estimation function is 47.40 kg./donum. This function indicates that an increase of 10 mm. of rainfall will increase wheat production by 3.3 kg./donum above the average (152.43 kg./donum).

For the pre-land reform Period II the best regression function is for Amadiya station (see Appendix I, Table I.1). This is probably because the average total rainfall for Period II is very much below the average total rainfall for the whole Period I, and therefore any precipitation increment would be likely to have the greatest effect on yield. This point must also be regarded as possibly qualifying our earlier assumption that agriculture before 1958 was more vulnerable to physical environmental factors than later. Less exceptional in this respect, Telafar station is selected for examination here because of its location in the predominatly grain growing foothill region and has the second best regression function; in Period II this function explains 62 per cent of the annual wheat yield variation (see Table 12.9). The standard error of the estimation function of 39.79 kg./donum, i.e. an increase of 10 mm, will increase wheat yield by 6.22 kg./donum above the average. Wheat production during this period was clearly very dependent upon rainfall.

The function of the post-land reform Period III explains 63 per cent of the annual wheat variation (see Table 12.9). The standard error of this estimation function is 40.95 kg./donum. In this function an increase of 10 mm. of rainfall will increase wheat yield by 3.88 kg./donum above the average. Although the response of wheat yield in this function is less than in the pre-land reform period function it still explains almost the same annual variation as for Period II. (see Table 12.9, functions No.2 and 3).

The last function (4) for the combination of the pre- and post-land reform periods explains 60 per cent of the annual wheat yield variation in Nineveh and it is very significant from the statistical point of view - the f-value is very high. The rainfall coefficient for this function shows that an increase of 10 mm. will increase wheat yield by 4.2 kg./donum above the average.

A comparison of these four functions reveals the following:-

1. The rainfall coefficient is at its highest level during the pre-land reform Period II (see Table 12.9, Function No.2). This means that wheat yield was very strongly affected by the rainfall during this period, whilst

Table 12.9 Regression of Wheat Yield on Total Rainfall at Telafar Station in Nineveh Province

No.	Functions	No.of Cases	r	r^2	S.E.	F	Notes
1	Y = 25.12 +0.33 TR (3.99)	27	.62	.39	47.40	15.92**	For the whole Period I
2	Y = -58.03 +0.622 TR (3.37)	9	.79	.62	39.79	11.37**	Pre-land reform Period II
3	Y = 3.658 +0.388 TR (4.30)	13	.79	.63	40.95	18.50**	Post-land reform Period III
4	Y = -4.185 +0.420 TR (5.50)	22	.76	.60	40.00	30.20**	The combination of the two Periods IV

Value in Brackets is the t-value for significance tests

* Total rainfall means seasonal total rainfall since there is no rainfall in the summer

** Significant at 1%

Source : Our Calculation

rainfall during Period III, post-land reform, had less effect on wheat yield. We also have to put this contrast in the context of two other trends. First the cultivated area expanded to include more marginal land in terms of rainfall in Nineveh province, as illustrated by Table 11.8 showing the cultivated area expanding at an average annual rate of 78.63 thousand donums during 1949/50 - 1975/76.[22] Secondly, since there was a slight improvement in wheat yield during the whole period, one may assume that there was some improvement in farming practice. (see p. 299).

2. The level of rainfall coefficient of function No.4, Period IV, lies between the level of the rainfall coefficient for Periods II and III due to the effect of the high rainfall coefficient during the pre-land reform period which is part of this series. Nonetheless, since there is an improvement in the regression function, one may also hypothesize that there was a dislocation period between 1958/59 and 1962/63 following land reform if we assume that other conditions remained the same. Comparing function No.4 with function Nos. 2 and 3 reveals there is not much difference in terms of standard error, or in terms of explaining the annual wheat yield variation, whilst in addition, this function is more accurate from the statistical point of view.

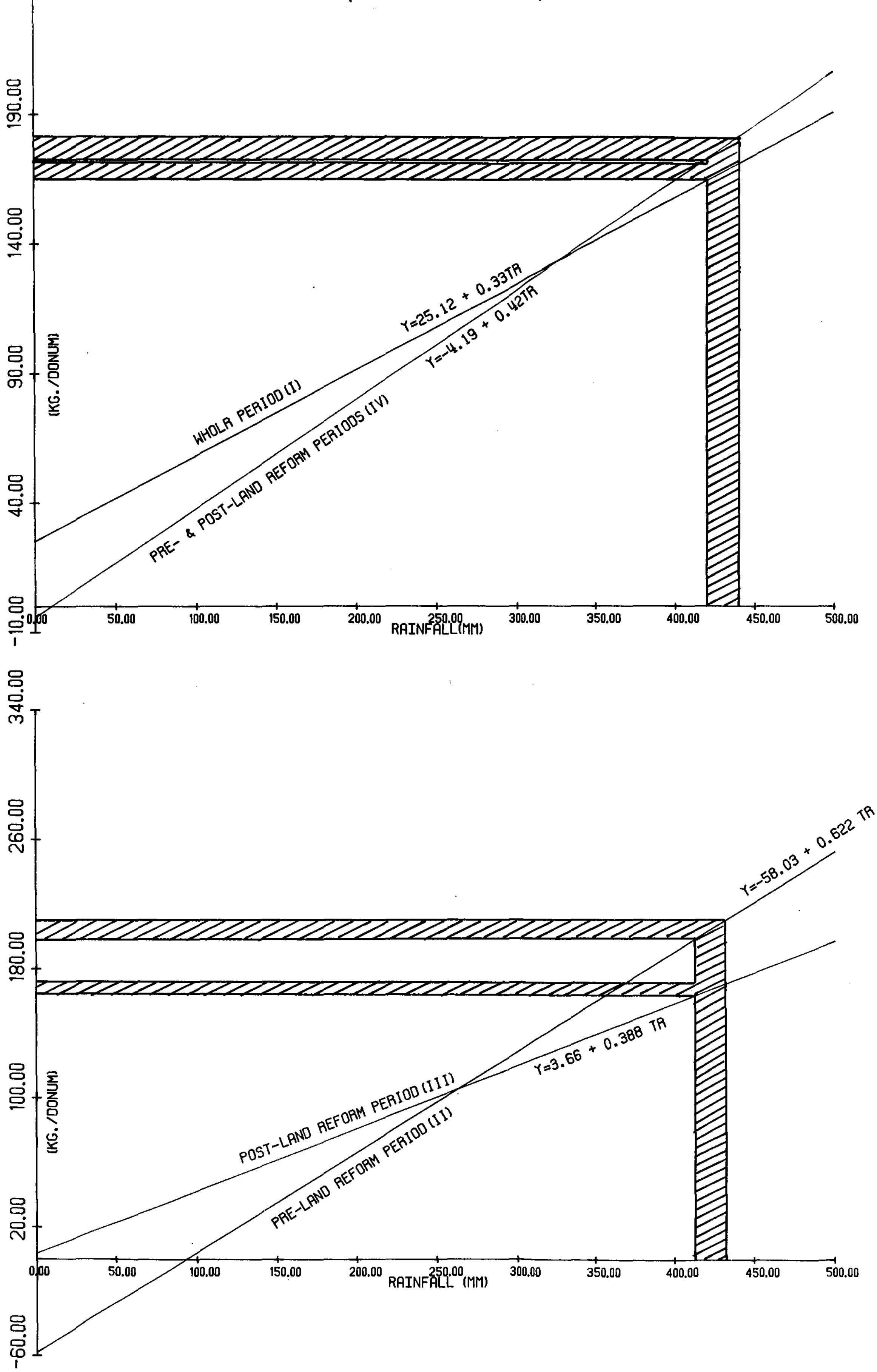
3. Fig. 12.1 further illustrates the influence of total rainfall on wheat yield for each function being especially strong during the pre- and post-land reform Periods II and III.

12.9.2 The Effect of Total Rainfall on Wheat Yield in Kirkuk Province

Data on rainfall is available for four stations in Kirkuk, most of which lie in the foothill region. Here, the average wheat yield in the province is regressed against the total rainfall at each station. The best results of these regressions are those for Hawija station and are shown in Table 12.10. Appendix I, Table I.1 shows the results of the

FIG. 12.1 THE EFFECT OF TOTAL RAINFALL ON WHEAT YIELD IN NINEVEH PROVINCE

(Telafar Station)



TR=TOTAL RAINFALL (MM)

...in yield kg/donum corresponding with

regressions for all four stations and it is clear the regression analyses for all of them are good.

Interpreting the first function in Table 12.10 reveals that this function explains 42 per cent of the annual wheat yield variation. The standard error of the estimation function is 45.2 kg./donum. This function shows that an increase of 10 mm. in the total rainfall would be expected to increase wheat yield by 4.56 kg./donum.

If we compare this function with that of Telafar station in Nineveh we see that both functions are very close in terms of explaining the variance, standard error and significance level. The only difference is the slightly higher total rainfall coefficient of the Hawija Project Station regression function. This shows how similar are the general environmental conditions in these two provinces.

The second function is that for the pre-land reform Period II which shows that an increase of 10 mm. in rainfall will increase wheat yield by 5.39 kg/donum in Kirkuk province. This function explains 74 per cent of the annual wheat variation in this province. Generally speaking, this function is more reliable than its counterpart function in Telafar station.

Function 3 explains 52 per cent of the annual wheat yield variation during the post-land reform Period III. The coefficient of rainfall of this function shows that an increase of 10 mm. in rainfall will increase wheat yield by 5.92 kg./donum above the average. The standard error of this estimation function is 43.66 kg./donum. However, the post land reform period in Hawija Project regression function is less significant from the statistical point of view than at Telafar. Although the regression function for the post-land reform period shows the effect of rainfall on wheat yield has increased in value, this is opposite to the general trend (see Appendix I, Table I.1 for details).

Table 12.10 The Regression of Wheat Yield on Total Rainfall at Hawija Project Station in Kirkuk Province

No.	Functions	No.of cases	r	r^2	S.E.	F	Notes
1	Y = 12.822 + .456 TR (4.21)	27	.64	.42	45.2	17.76**	For the whole Period I
2	Y = -2.975 + .539 TR (4.50)	9	.86	.74	33.66	20.28**	Pre-land reform Period II
3	Y = -18.994+ .592 TR (3.46)	13	.72	.52	43.66	11.95**	Post-land reform Period III
4	Y = -9.853 + .561 TR (5.63)	22	.78	.61	38.10	31.67**	The combination of the two Periods IV

Value in Brackets is the t-value for significance tests

** Significant at 1% level

Source : Our Calculation

As in the case of Nineveh province, the most accurate function from the statistical point of view is function No.4 in Table 12.10. This function explains 61 per cent of annual wheat yield variation. The standard error of this estimation function is 38,10 kg/donum. Comparing this function with the similar one in Telafar station shows both of them are very close from the accuracy point of view. The only difference is between the coefficient of rainfall in both equations. Fig. 12.2 shows wheat yield response to total rainfall in Kirkuk province.

12.9.3 The Effect of Total Rainfall on Wheat Yield in Arbil and Sulaimaniya Provinces

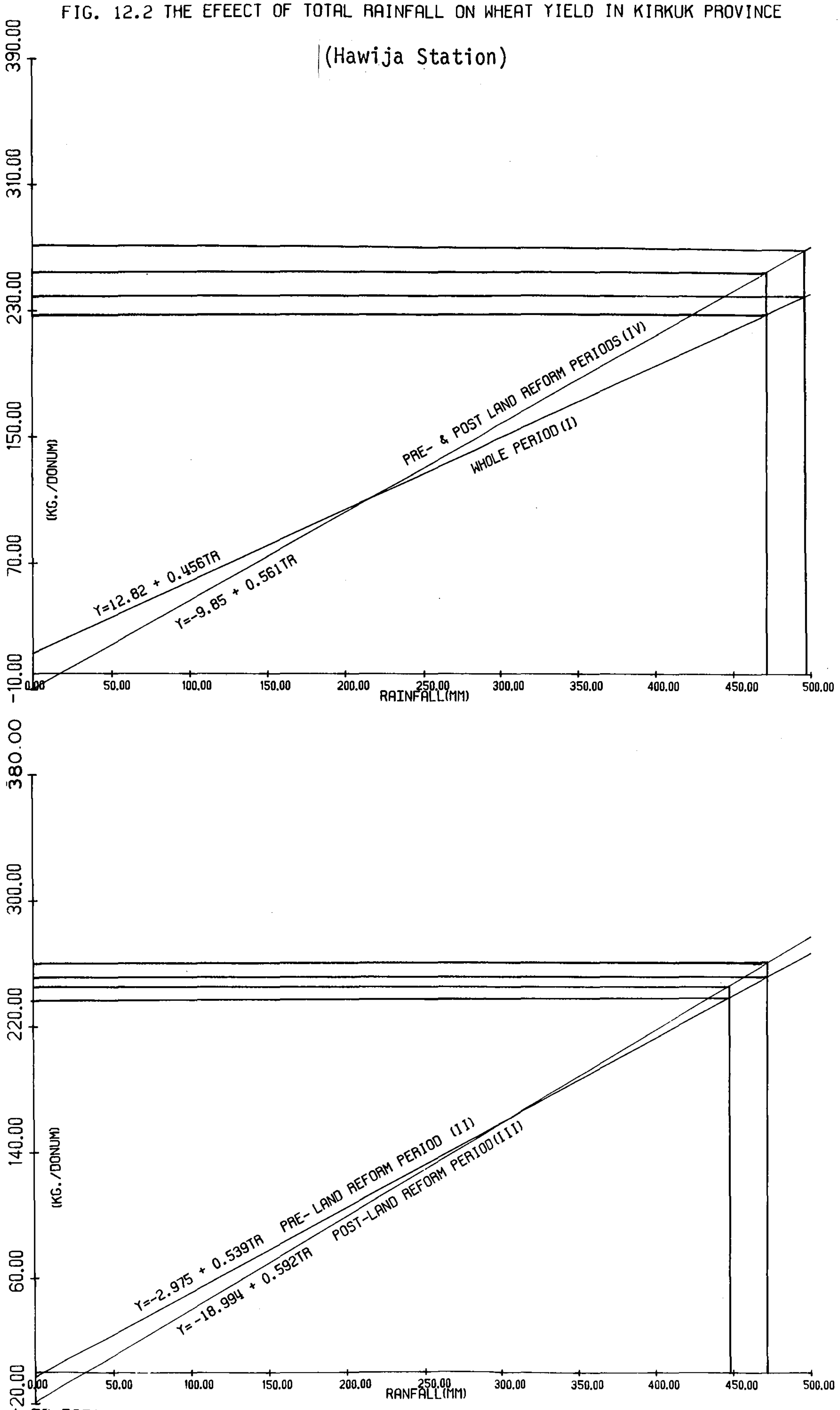
Most of the territory of these two provinces lies in the high mountain region in which cereal production is restricted to small valleys. Most of the meteorological stations are located at higher altitudes than the stations utilised earlier, and most of the former stations receive greater annual rainfall (see Table 11.14).

Only one station in Arbil province gives analytical results superior to the general level and the significance of regression functions for these provinces is very much lower than the significance of those functions examined earlier. Shaqlawa station has been selected to illustrate the position in Arbil and Sulaimaniya - see Table 12.11. Data for other stations are given in Appendix I, Table I.1.

As far as Sulaimaniya province is concerned, regression analysis of wheat yield on total rainfall showed no significance for any station, and no improvement in results followed the testing of a non-linear formula. The results of these regressions can be seen in Appendix I, Table I.1. Regression analysis therefore confirms the earlier correlation indications that there is a low statistical relation between wheat yield figures for the provinces and the rainfall as recorded at meteorological stations.

FIG. 12.2 THE EFEECT OF TOTAL RAINFALL ON WHEAT YIELD IN KIRKUK PROVINCE

(Hawija Station)



TR=TOTAL RAINFALL (MM)

Table 12.11 The Regression of Wheat Yield on Total Rainfall at Shaqlawa Station in Arbil Province

No.	Functions	No. of cases	r	r^2	S.E.	F	Notes
1	Y = 76.124 + .048 TR (2.15)	27	.40	.16	40.44	4.63*	For the whole Period I
2	Y = 67.145 + .069 TR (1.12)	9	.39	.15	49.71	1.24	Pre-land reform Period II
3	Y = 73.772 + .048 TR (2.31)	13	.57	.33	31.05	5.32*	Post-land reform Period III
4	Y = 76.755 + .050 TR (2.26)	22	.45	.20	38.03	5.10*	The combination of the two Periods IV

Value in Brackets is the t-value for significance tests

* Significant at 5% level

The reasons for this can be listed briefly as follows:-

1. These two provinces are not major production areas of wheat and wheat production is not as dominant an element in this agriculture. Many variations in wheat yield could be ascribed to factors other than rainfall in such conditions.

2. Since total average rainfall in these highlands is higher and closer to the theoretical optimum for wheat yields, under these conditions the relationship between yield and rainfall can, statistically, be expected to be lower.

3. Other micro-climatical, topographical and soil conditions may have stronger and more variable effects in this less environmentally homogeneous region.

4. The location of the Met.station may not represent the real conditions in cereal growing areas. Again, improvement in agroclimatology is clearly required.

The following points can be concluded from the foregoing discussion.

First, total rainfall very strongly affects wheat yield in the foothill region. The best regression functions are obtained at Telafar in Nineveh province and Hawaja Project in Kirkuk province. Both of these functions prove that a large proportion of the annual wheat yield variation can be attributed to variations in total rainfall, especially in the pre-land reform period when the rainfall coefficients are slightly higher than for other periods. The range of explanation due to total rainfall, which is shown in these functions, is between 39 - 74 per cent. Secondly, we may safely assume that the Period IV 22 year regression function for total annual rainfall at Telafar and Hawija Project provides a basis for forecasting wheat yield in these two provinces.

12.10 The Effect of Monthly Rainfall on Wheat Yield

The second set of regression analysis results are presented for wheat yield as a dependent variable and monthly rainfall as independent variables for each of the selected meteorological stations in the rainfed area and for the same selected periods.

The aims of this regression analysis of the effect of monthly rainfall on wheat yield for each province are twofold. First, they may provide some useful information for developing irrigation as supplementary to rainfall. Secondly, to explore the possibilities of making pre-harvest forecasts (before the end of the harvest) of wheat yields, with stated reliabilities for each province : such early forecasting could have many useful implications (see pages 382-383).

The results of these regression functions are given as a whole in Appendix I, Table I.2. Considering the effect of rainfall for each month during the growing season, the following summarised conclusions can be drawn:-

1. October rainfall does not appear in the regression function very frequently, i.e. October rainfall has little effect on wheat yield. Nevertheless, when it does appear in the regression function, it has a negative coefficient in most cases, which means that October rainfall has a negative influence on the final yield (see Table 12.12). The reasons for this have been explained earlier (see page 472). October rainfall does appear in a very few regression functions with a positive coefficient but this is statistically of even less importance.

2. It seems that early rainfall occurring during November is a primary factor in the determination of final wheat yield. November rainfall appears in many of the regression functions in most periods. The effect of November rainfall itself on the final wheat yield is positive, except for two stations in the post land reform period (see Table 12.12).

In crop seasonal growth terms we are now dealing with the germination period which occurs from late November to early December. Arthur Coffing indicated in his study in Turkey that because a significant proportion of the wheat crop is autumn-planted and is still sown by broadcasting, as is also true in our region, autumn rainfall is important to the extent that it ensures adequate seedbed preparation and germination. While a dry autumn means poor germination, too much autumn precipitation can mean delayed planting.[21] This statement explains the importance of November rainfall and also it partially explains the occasional negative influence of October rainfall in the final wheat yield.

3. The number of December and January appearances in the regression functions is very small in comparison with November rainfall. December and January rainfall tends to have less effect on the final yield, for reasons explained earlier (see page 474). Nonetheless when they appear in the regression function, they show positive and negative coefficients (see Table 12.12). This could be related to the average rainfall of these two months during the selected period when rainfall occurs, i.e. whether it is at the beginning or at the end of the month, and the effect of other climatic factors, etc.

4, Late rainfall or spring rainfall, which occurs during February, March and April, has a strong influence on the final wheat yield. February rainfall, in fact, shows a generally positive effect on the final wheat yield, with a negative in only one function. March and April rainfalls always have a positive influence on the final yield (see Table 12.12). The importance of spring rainfall here is parallelled in Coffing's Turkish study.[22]

Given the active growth of the plant during these months which includes flowering and seed formation, plant requirements for water are high. C.C. Webster and P.N. Wilson have indicated that shortage of water during the formation of reproductive organs and flowering can seriously reduce cereal grain yields.[23]

5. Finally, the influence of May rainfall on the wheat yield is rather complicated and more puzzling with a mixture of negative and positive influences. In the whole period and in the pre-land reform period May rainfall shows both a positive and negative effect on the final yield. But for the post-land reform period and the 22 year period, May rainfall shows only very strong positive influences. It appears a reasonable assumption that May rainfall can have negative influence on the final yield, if one also assumes that the crops are mature and ready for harvesting. In other words, there is no need for water. However, May rainfall for the 22-year and post-land reform periods has shown a positive influence on wheat yield. May rainfall also shows a positive influence on wheat yield in Turkey.[24] In the case of Turkey, where the Anatolian harvest takes place during July and August this would have been expected. In Iraq it is more puzzling. Nonetheless, it seems the most likely reasons for this situation are as follows (see pp.477-478).

First, May rainfall is highly variable from season to season (see Appendix H, Table H.7 for details) and it may be dangerous to attach too great an importance to particular results. Secondly, May rainfall usually comes in the form of showers. If these showers are very heavy, they may destroy the crops, and if these showers are light and fall early in the month they can be beneficial or at least not damaging.

It may be concluded in general that autumn rainfall during November is very important in determination of the final wheat yield, and also that February, March and April rainfall have a positive influence on the final yield.

Table 12.12   The Effect of Monthly Rainfall on Wheat Yield in The Rainfed Area

Station	Whole Period 27 - year, I								Pre-land reform Period 9 year, II								Post-land reform Period 13 year, III								Combination of pre- and post-land Ref.Per. 22 years, IV							
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
Sinjar		+					+								+								+								+	
Mosul		+				+				+				+									+			+				+		
Telafar			+		+	+								+		-			+					+		+			+	+		
Aqra		+										+												+				+				+
Sersank		+				+																	+	+						+		
Dohuk		+							+	+			-	+				+								+						
Amadiya														+			+		+	+	-											
Zakho	+					+						-		+						+				+	+					+		
Kirkuk							+							+			-	-						+	-					+		+
Hawija						+			-					+			-					+		+	-					+	+	
Iftikhar		+				+	+						+		+	+	-	+							-	+			+		+	+
Tuz-Khurmatu						+		-						+	+	-														+		
Shaqlawa		+			+			+									-			+				+		+			+			+
Arbil	-					+								+										+								
Rawanduz		+																						+			+					
Salahuddin																	-	-						+								+
Dokan																								+								
Sulaimaniya		+		-		+		-	-	+															-	+	-					
Halabja										+						+						+				+						
Bakrajo		+																	-					+		+						
Penjwin		+								+																+						
Chwarta	+	+			+					+	-		+													+	-		+			

12.11 The Effect of Monthly and Total Rainfall on Wheat Yield

After a careful study of the correlation matrix between monthly rainfall and total rainfall, it is found that the correlation between them is not very high. In other words, there is no risk of multicollinearity.[25]

In order to improve the regression function, it was decided to use monthly rainfall as well as the total rainfall in one formula.

The results of the regressions for the four periods can be seen in Appendix I, Table I.3. Generally speaking, it can be seen from these tables that there is not much improvement in the regression function results. Most of the regression functions appear in this regression without total rainfall as a significant factor. This indicates that seasonal/monthly rainfall distribution is a very useful measure for determining the final wheat yield.

Nonetheless, in some cases where total rainfall is included in the function side by side with monthly rainfall for all periods, the regression formulas show some improvement in some statistical parameters such as the standard error or the coefficient of determination (R^2).

12.12 The Effect of Temperature on Wheat Yield

As mentioned before,data on temperature is available at two stations, one in Kirkuk province and the other one in Nineveh province. The form in which this data is available is average monthly data for minimum and maximum temperature. Three sets of regression analysis have been calculated between wheat yield as a dependent variable and first, average monthly maximum temperature, second, average monthly minimum temperature and third, average monthly mean temperature. In addition, the average seasonal temperature, which is the average of the eight months of the growing season, has been included for each category.

12.12.1 The Effect of Average Monthly Maximum Temperature on Wheat Yield

The results of these regression functions can be seen in Appendix I, Table I.4 for the two stations for all periods. It appears for the whole period (1949/50 - 1975/76) that average November maximum temperature and average seasonal maximum temperature negatively affect the final wheat yield in both stations. In other words, any decrease in the average November maximum temperature or average seasonal temperature down to a certain level will benefit wheat yield. This may be the case if other climatic conditions, such as seasonal precipitation and radiation, are considered in the context of an arid and semi-arid climatic regime. Nonetheless, both of these functions explain 49 and 51 per cent of the annual wheat yield variation in Kirkuk and Nineveh provinces respectively.

In the case of the pre-land reform period, average April maximum temperature negatively affects wheat yield at Kirkuk Station. This negative influence could be related, as it is said before, to soil moisture or to the grain development itself.[26] At Mosul station, on the other hand, average December and average seasonal maximum temperatures negatively influence wheat yield, whilst average January maximum temperatures positively influences wheat yield (see Appendix I, Table I.4 for details). It is not surprising that January has a positive influence on the final wheat yield, since it is the coldest month of the growing season. Any increase in temperature might encourage plant growth. The regression function for the pre-land reform period explains 73 and 96 per cent of the annual wheat yield variation in Kirkuk and Nineveh provinces respectively, which is higher than for the whole period.

Multiple regression for the post land reform period shows that average November and May maximum temperatures negatively affect the final wheat yield at Kirkuk station. At Mosul station, it appears that only average December maximum temperatures negatively affect wheat yield (see Appendix I, Table I.4 for details). The negative effects of average November and December maximum temperatures have already been explained before (see page 485). As far as May is concerned, it seems that high temperature during ripening time reduce the grain weight.[27]

The results of the regression of the combination of the pre- and post-land reform period show that average November and average seasonal maximum temperatures negatively affect the final wheat yield at Kirkuk Station. The reasons for this were explained earlier (see page 484). At Mosul Station, average February maximum temperature positively affects the final wheat yield, whilst average seasonal maximum temperature negatively affects wheat yield. The reason for positive effect of average February maximum temperature is the same as in the case of January (see page 510).

Discussing the accuracy of these functions reveals that the pre-land reform period is more accurate from the statistical point of view. As stated previously, these two functions explain 73 and 96 per cent of the annual wheat variation in Kirkuk and Nineveh provinces respectively. Kirkuk station, however, shows that the regression functions for the post-land reform period, the combination of the pre- and post land reform periods and the whole period are in second, third and fourth place respectively in terms of explaining the annual wheat yield variation (see Appendix I, Table I.4 for details).

Regression functions in Nineveh province show that the combination of the two periods, the whole period and the post-land reform period are in second, third and fourth place respectively from the statistical accuracy point of view (see Appendix I, Table I.4 for details).

Generally speaking, it seems from the evidence we have from these results that average seasonal maximum temperature is an important factor in determining the final wheat yield. Any decrease in average seasonal maximum temperature benefits the final yield. In addition, average November maximum is also very important because it appears in many functions. Other months, such as December, January, and April also have some influence on wheat yield as is shown in the regression function.

12.12.2 The Effect of The Average Monthly Minimum Temperature on Wheat Yield

Briefly it appears that minimum temperature has little effect on wheat yield since for some periods and some stations it is not a significant variable in the regression function (see Appendix I, Table I.4 for details)* For example, there are no significant variables in the regression function at Mosul Station either for the whole Period I or for the combination of the pre- and post land reform Period IV. Also, there are no significant variables in the regression functions for the post land reform Period III at Kirkuk station (see Appendix I, Table I.4 for details).

Nonetheless, the regression function for the whole period at Kirkuk Station reveals that average December minimum temperature has a negative influence on the final wheat yield. This function explains only 23 per cent of the annual wheat yield variation in Kirkuk province, which is relatively low by the standard of the regression function for the average monthly maximum temperature for the same period (see Appendix I, Table I.4 for details).

In contrast, the best regression function of average monthly minimum temperature is obtained at Kirkuk Station for the pre-land reform period. This function explains 97 per cent of the annual wheat yield variation in Kirkuk province. This function also shows average November, February and

* The significance of each variable in the regression function is determined by the value of t at a certain level, usually 5 or 1 per cent level.

April minimum temperatures have a negative effect on the final wheat yield, whilst average March minimum temperature has a positive effect (see Appendix I, Table I.4 for details). Regression functions at Mosul Station show that the average seasonal minimum temperature has only a negative influence on the final wheat yield, and it explains only 42 per cent of the annual wheat yield for the same Period, II.

At Mosul Station, however, the regression function for the post-land reform period shows that average February and May minimum temperatures have a negative influence on the final wheat yield in Nineveh province, whilst average April minimum temperature has a positive influence on the final wheat yield (see Appendix I, Table I.4 for details). This function explains 66 per cent of annual wheat yield variation in Nineveh province. There are no significant variables in the regression function in the case of Kirkuk Station for the post-land reform period.

Only one regression function appears for the combination of the pre- and post-land reform periods, IV, this at Kirkuk station. This function shows that average December minimum temperature has a negative influence on the final wheat yield, but it explains only 24 per cent of the annual wheat yield variation in Kirkuk province.

Summing up the effect of average monthly minimum temperature on wheat yield reveals that average November minimum temperature negatively affects wheat yield. This can be explained by first, the direct effect on the plant during the germination period and, secondly, the indirect effect through influencing the availability of soil moisture for germination, especially if the average November rainfall is considered.

It is rather difficult to give a firm reason for the negative effect of average December and February minima on wheat yield other than by the effect of average minimum temperature on the plant itself, even though winter-wheat can withstand freezing temperatures.[28]

Average March and April minimum temperatures positively affect wheat yield, and this could be related to the effect of average minimum temperature during these months on seed development during this period.[29] Average May minimum temperature negatively affects wheat yield.

12.12.3 The Effect of Average Monthly Mean Temperature On Wheat Yield

The last use of regression analysis to study the effect of temperature is by using average monthly mean temperature as well as the average seasonal mean temperature (the average of eight months) in the regression function.

Appendix I, Table I.4 shows the results of these regression functions. It is clear from these that average seasonal mean temperature appears as a significant variable in all functions, except in the pre-land reform period in both stations. The effect of the average seasonal mean temperature on wheat yield is negative, as can be seen from the sign of the coefficient in the regression function. This means that any decrease in the average seasonal mean temperature will benefit the final wheat yield. In addition to that, it seems that average November mean temperature is the second most important variable. It appears in the pre-land reform period at Mosul Station, whilst at Kirkuk Station, it appears in the whole period regression function and in the regression function for the combination of the pre- and post-land reform periods. The influence of average November mean temperature is also negative. This is quite obvious since both average monthly minimum and maximum temperature negatively influence the final wheat yield. The last variable which shows a significant influence on wheat yield is average April mean temperature. This month appears in the pre-land reform period and in the post-land reform period, and its effect on wheat yield is negative and positive respectively.

Examining the accuracy of these functions reveals they lie between the accuracy of the average monthly maximum temperature and average monthly minimum temperature. This is not surprising since average monthly mean temperatures in these cases are the means of minimum and maximum temperature. Thus, the effect of the low relation between wheat yield and average monthly minimum temperature has affected the accuracy of these functions.

Finally, it can be concluded from the previous discussion on the effect of temperature on the final wheat yield that maximum temperature has the most influence on the final yield. This influence is usually negative; any decrease in maximum temperature will benefit the yield. This negative influence of maximum temperature on wheat yield could be as a result of direct relation between plants and maximum temperature, or indirectly through soil moisture and evaporation. For example, the negative influence of average November maximum temperature on wheat yield is most likely to be attributed to high temperature producing high evaporation and consequently low soil moisture, especially if one considers the factor importance of average November precipitation. On the other hand, the negative influence of maximum temperature on wheat yield at the end of the growing season is mainly a result of direct influence on the plant itself, particularly through stunting grain development.[30,31] In addition, the average seasonal maximum temperature has shown a negative influence on the final wheat yield.

Minimum temperature, however, appears to be less important than maximum temperature. This is probably due to the fact that winter conditions in these regions are not very harsh in the areas where wheat is grown. Although minimum air temperature may drop to $0^{o}C$ or below in some seasons, field conditions can be more favourable, and the wheat plant can survive hard winter conditions if the roots are not damaged.[32]

Average monthly and seasonal mean temperature follows almost the same pattern as maximum temperature. Average November mean temperature has a negative influence on the final yield. In general, it appears that average seasonal mean temperature is a very important factor in determining the final wheat yield.

12.13 The Effect of Relative Humidity on Wheat Yield

As in the case of temperature, monthly data on relative humidity is available at two stations, Mosul and Kirkuk. Regression analysis between wheat yield as the dependent variable and monthly relative humidity recordings as independent variables has been carried out for both stations for all periods. The results of these regressions can be seen in Appendix I, Table I.5.

It is clear from this set of regression functions that April relative humidity has a positive influence on the wheat yield in that it appears in five functions out of eight, proving the importance of April relative humidity during the late active growth period. May relative humidity also shows a positive influence on the final wheat yield. March relative humidity shows a positive influence on wheat yield during the pre-land reform period at Mosul station. October and February relative humidity, on the other hand, negatively affect final wheat yield at Kirkuk and Mosul stations respectively during the post-land reform Period III.

The general conclusion that late relative humidity during the active growth period of March and April is very important, is mainly due to the fact that relative humidity affects photosynthesis which is very important during this period.(33) In May relative humidity can play an important role either through its effect on photosynthesis or through its association with available moisture at a time when mean precipitation is low and average mean temperature is high.

12.14 Forecasting Wheat Yield From Meteorological Data

F. Yates distinguished between forecasts and estimates by proposing that "forecasts" should denote an estimate of the yield of the crop furnished at some date well before the harvest.(34) Therefore, there are many ways which yield forecasts can be made.(35) Here an attempt will be made to forecast wheat yield from meteorological data, on the basis of what has been established in this study.

Although it would be useful to produce a unique model for forecasting wheat yield from meteorological observations for the rainfed area of Northern Iraq, it seems, however, rather difficult if one is limited to the utilisation of a small number of meteorological records of elementary or primary forms of factors. The results so far are far from encouraging. Variations between local climatic conditions and their influence on wheat yield, in particular, may prevent one from producing a model for the whole area. It is clear, for example, that rainfall is less clearly correlated with cereal (wheat and barley) yields in the upland regions with relatively scattered, small growing zones. On the other hand, in the foothills regions rainfall has a significant effect on cereal yield at all stations in this region and in Nineveh and Kirkuk provinces most specifically. Moreover, the geographical aggregation of agricultural and meteorological data from a few stations may affect the real validity of demonstrating the relation between crop yield and weather variables.[36]

Until more detailed investigations are carried out, a forecasting model for each province or district could, however, be very useful for the time being. This is the common procedure in many Middle Eastern countries such as Jordan, Syria, Turkey and Egypt.[37,38,39]

It was clear from the previous analysis that the relation between rainfall (monthly and total) was not high in the upland region, namely Sulaimaniya and Arbil provinces. Since these two provinces produce only 22.6 per cent of the total wheat production in the rainfed area, no attempt is made here to make wheat yield forecasts for these two provinces in the absence of more detailed (spatially and in type) data on weather conditions.

Most of the regression functions previously reviewed in this chapter can be used for seasonally early forecasts, but further regression functions have been developed for Nineveh and Kirkuk provinces. These functions are based on combinations of different weather factors as independent variables and wheat yield as a dependent variable.

For forecasting wheat yield in Nineveh and Kirkuk provinces, weather variables have been drawn from two meteorological stations in each province; Mosul and Telafar stations in the case of Nineveh province and Kirkuk and Hawija stations in Kirkuk province. Data records on rainfall are obtained from Telafar and Hawija in Nineveh and Kirkuk provinces respectively, whilst data on temperature regime and relative humidity are obtained from Mosul and Kirkuk stations.

The principal reason behind the combination of temperature and relative humidity from an urban station in each province (Mosul and Kirkuk) and the rainfall data from a rural station in each province (Telafar and Hawija), is that rural conditions are obviously paramount in discussion of wheat production. Unfortunately only the urban stations have an adequate time span of temperature and relative humidity data, so in order to bring some rural influence to the analysis it was decided to combine data for Mosul and Telafar in Nineveh province and Kirkuk and Hawija in Kirkuk province. Since in both cases the stations combined are relatively close (50 km. and 60 km. apart respectively) it is assumed that variations in the parameters believes the stations will be insignificant.

Tables 12.13 and 12.14 show these regression functions for Nineveh and Kirkuk provinces respectively. An examination of these functions reveals that they are more accurate in terms of R, R^2, and standard errors than the previous functions. Their standard errors are smaller than some of those forecasting functions reported by Al-Sherbini (see reference No.3 , pp.185-187). So, they can provide forecasts with a certain degree of accuracy. Appendix I,Table I.6 shows the actual forecasted wheat yield for the whole period which are based on utilizing functions No.I and IV of Tables 12.13 and 12.14 for Nineveh and Kirkuk provinces.

The range of accuracy of these forecasting functions is between $\pm$ 6.96 to $\pm$ 12.86 per cent of the average actual wheat yield in Nineveh province and ranging between $\pm$ 6.38 to $\pm$ 27.73 per cent of the average actual wheat yield in Kirkuk province. These forecasts are probably more accurate than the official figure in some cases, and hence this may increase the validity of wheat forecasts in Northern Iraq. Table 12.16 shows the relative accuracy (positive and negative) of the forecasted wheat yield as against actual yield for Nineveh and Kirkuk provinces for the whole period 1950-1976 utilizing the 22 year period formula (No. 4 in Tables 12.3 and 12.4). It is clear that during the five year period between 1959 and 1963 the discrepancy is most obvious (see also Fig. 12.3B for details) for reasons associated with post-land reform farming dislocation. For the 13 post-land reform years only 4 of the 13 years show a discrepancy of more than 10 per cent in Nineveh province, whilst in Kirkuk only 4 are less than 10 per cent. Also, it is clear from Table 12.16 that no trends are observable in either province or in any period or sub-period; this appears to confirm the absence of any overall trend in wheat productivity due to improved management, inputs, etc. (see Chap. 3 to 7).

Comparing the forecasting results for both Nineveh and Kirkuk provinces, Tables 12.13 and 12.14 show that the forecasting functions

Table 12.13 Forecasting Equations for Wheat Yield at Telafar Station in Nineveh Province

No.	Function	No. of cases	R	R^2	S.E.	F - Value
1	Y = 176.42 + 0.69 R4 + 0.30 R5 - 25.65 MAT 3 - 10.96 MIT6 (3.74) (1.76) (6.90) (2.26) + 4.99 MAT8 + 3.03 RH7 (2.27) (4.64)	27	.91	.82	28.78	15.17
2	Y = 8.73 - 18.55 MIT2 + 7.25 RH6 (3.39) (4.83)	9	.94	.89	22.97	24.55
3	Y = 434.84 + 0.34 TR - 24.65 MAT3 + 18.88 MIT7 - 3.54 RH3 (16.15) (13.15) (7.85) (6.23)	13	.99	.99	9.16	145.50
4	Y = 748.66 + .53 R7 + .16 TR - 16.40 MAT3 + 8.56 MIT4 - 8.24 MAT5 (5.95) (4.80) (9.93) (4.74) (4.43) + 20.74 MIT7 - 23.62 MIT8 - 2.80 RH5 (6.35) (11.39) (4.94)	22	.99	.98	11.14	79.29

Value in Brackets is the t-value for significance tests

R4 = January Rainfall
R5 = February Rainfall
MAT3 = Average December Maximum Temperature
MIT6 = " May Minimum "
MAT8 = " May Maximum "
RH7 = April Relative Humidity
MIT2 = Average November Minimum Temperature
RH6 = March Relative Humidity
TR = Total Rainfall
R7 = April Relative Humidity
MIT7 = Average April Minimum Temperature
RH3 = December Relative Humidity
MIT4 = Average January Minimum Temperature
MAT5 = " February Maximum "
MIT8 = " May Minimum "
RH5 = February Relative Humidity

in Nineveh province show a greater degree of accuracy than those for Kirkuk province, e.g. the standard errors. Although the available data does not show there are significant differences between wheat yield or weather conditions in both provinces, the difference in forecasting accuracy between Nineveh and Kirkuk provinces can only be explained by soil conditions, seed varieties, farming practices, etc., and these factors cannot be determined without field investigations (see Table 12.16). Fig. 12.3, however, shows the actual and forecasted wheat yields in both Nineveh and Kirkuk provinces. Two points emerge from this figure; first, it confirms the existence of a dislocation period following land reform between 1959 and 1963, and secondly, it shows the superiority of the forecasting functions in Nineveh province.

The utility and validity of using these formulae ultimately depends on the purpose and use of the forecasts (see pp.382-383). Nevertheless, it seems that the function for the post-land reform period, and the function for the combination of the pre-land post-land reform periods could be used for forecasting, within the stated margins of error particularly since current pre-harvest estimations are not very accurate.

12.15 Conclusion and Final Remarks

We have already noted the importance of weather-crop studies and how they could provide much valuable information (see pages 382-83). In this chapter an attempt was made to study weather-crop relationship in Northern Iraq by using certain weather factors and wheat yield in the rainfed area of Northern Iraq during 1949/50-1975/76. This whole period, however, was further divided into three sub-periods; first, the pre-land reform period (1949/50-1957/58), secondly, the post-land reform period (1963/64-1975/76)

Table 12.14 Forecasting Equations for Wheat Yield at Hawija Project Station in Kirkuk Province

No.	Function	No. of cases	R	R^2	S.E.	F
I	Y = 98.046 + 1.19 R6 - 10.2 MIT6 - 2.32 RH1 + 2.70 RH2 (5.68) (1.97) (2.64) (3.21)	27	.82	.68	35.86	11.48
II	Y = -123.98 + 1.09 R6 + 9.88 MAT1 - 7.41 MAT5 (19.80) (6.25) (4.85)	9	.99	.99	8.25	149.66
III	Y = 501.49 + 6.70 R8 + .46 TR - 6.67 RH3 - 1.46 RH4 (6.65) (4.17) (5.11) (2.11)	13	.93	.93	19.52	26.68
IV	Y = 40.881 - 4.35 R1 + .50 R6 + .319 TR (2.07) (1.85) (2.37)	22	.85	.73	33.82	15.86

Value in Brackets is the t-value for significance tests

R6 = March Rainfall
MIT6 = Average March Minimum Temperature
RH1 = October Relative Humidity
MAT1 = Average October Maximum Temperature
MAT5 = Average February " "
R8 = May Rainfall
TR = Total Rainfall
RH3 = December Relative Humidity
RH4 = January " "
R1 = October Rainfall
RH2 = November Relative Humidity

FIG. 12.3B THE DIFFERENCE BETWEEN ACTUAL AND FORECASTED WHEAT YIELDS IN NINEVEH & KIRKUK PROVINCES

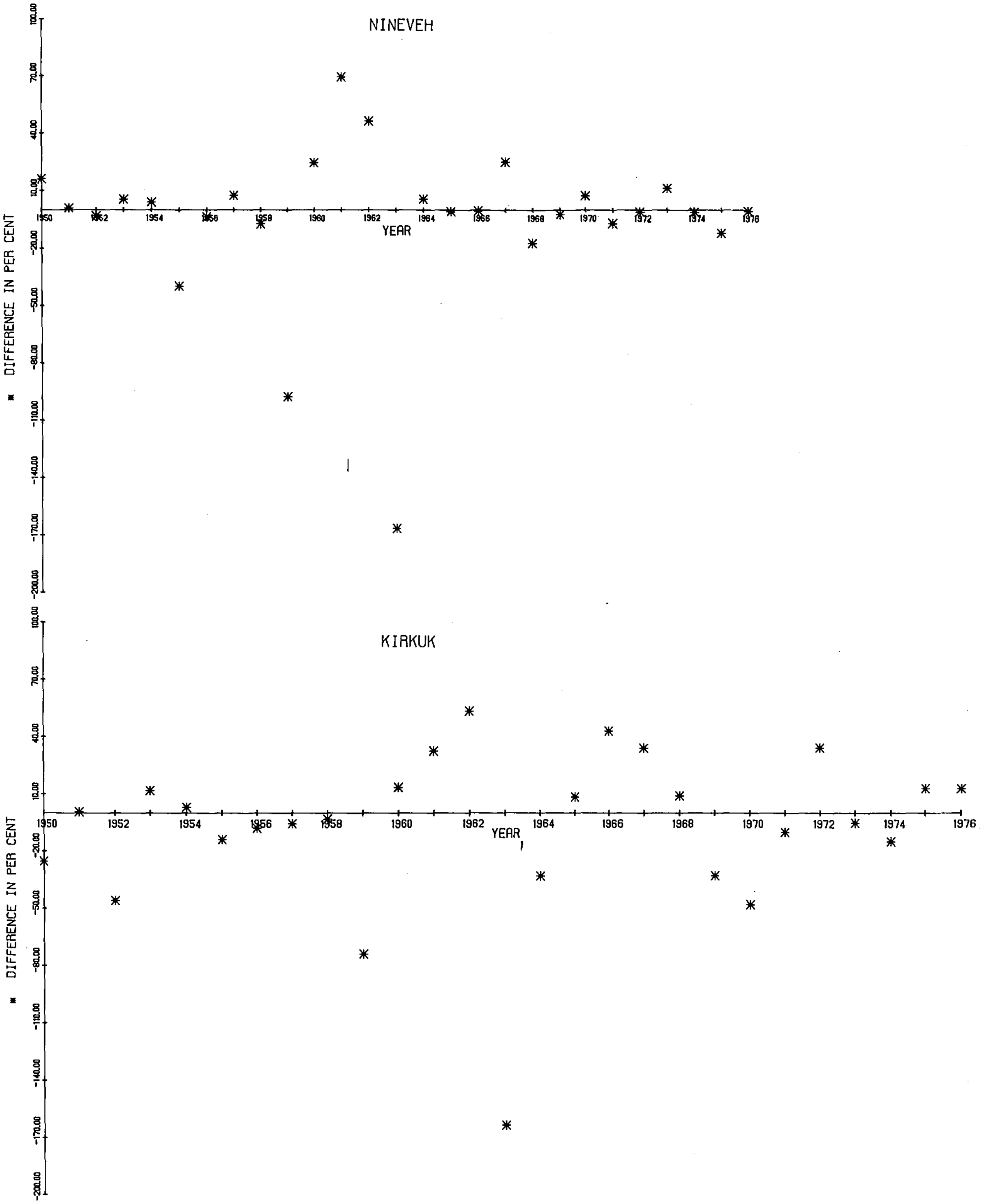
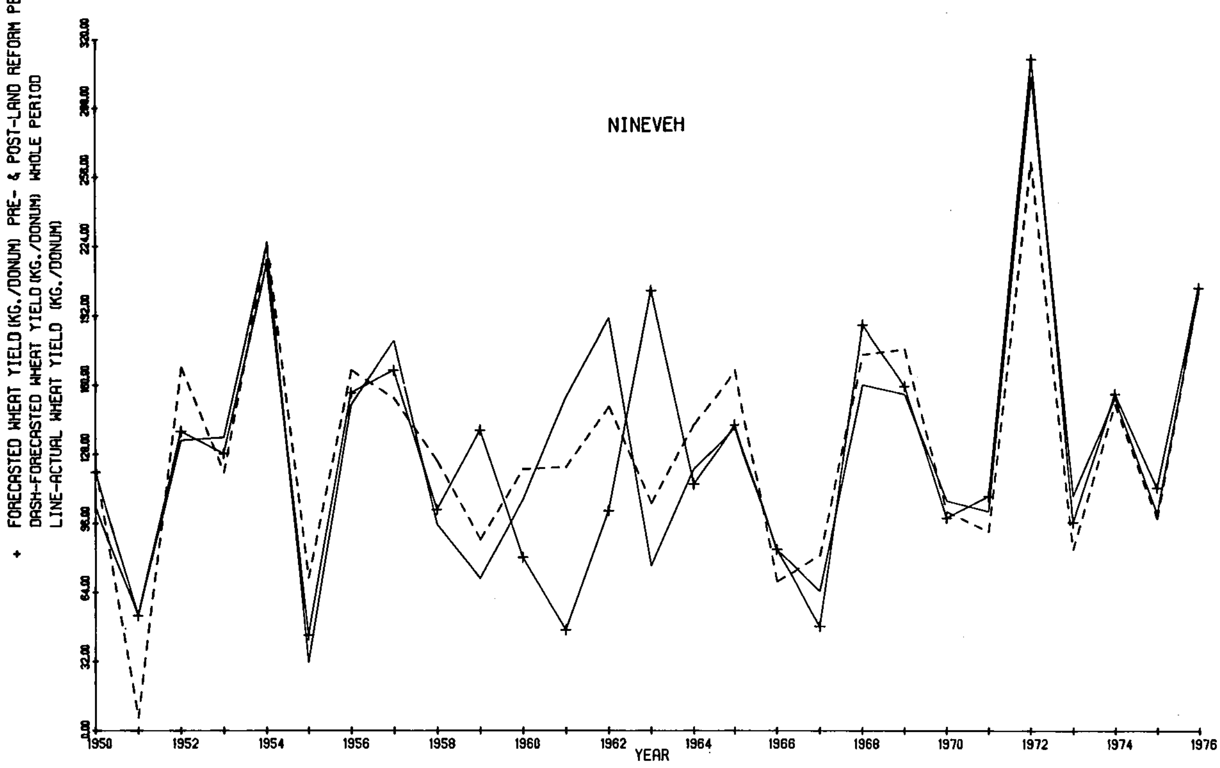
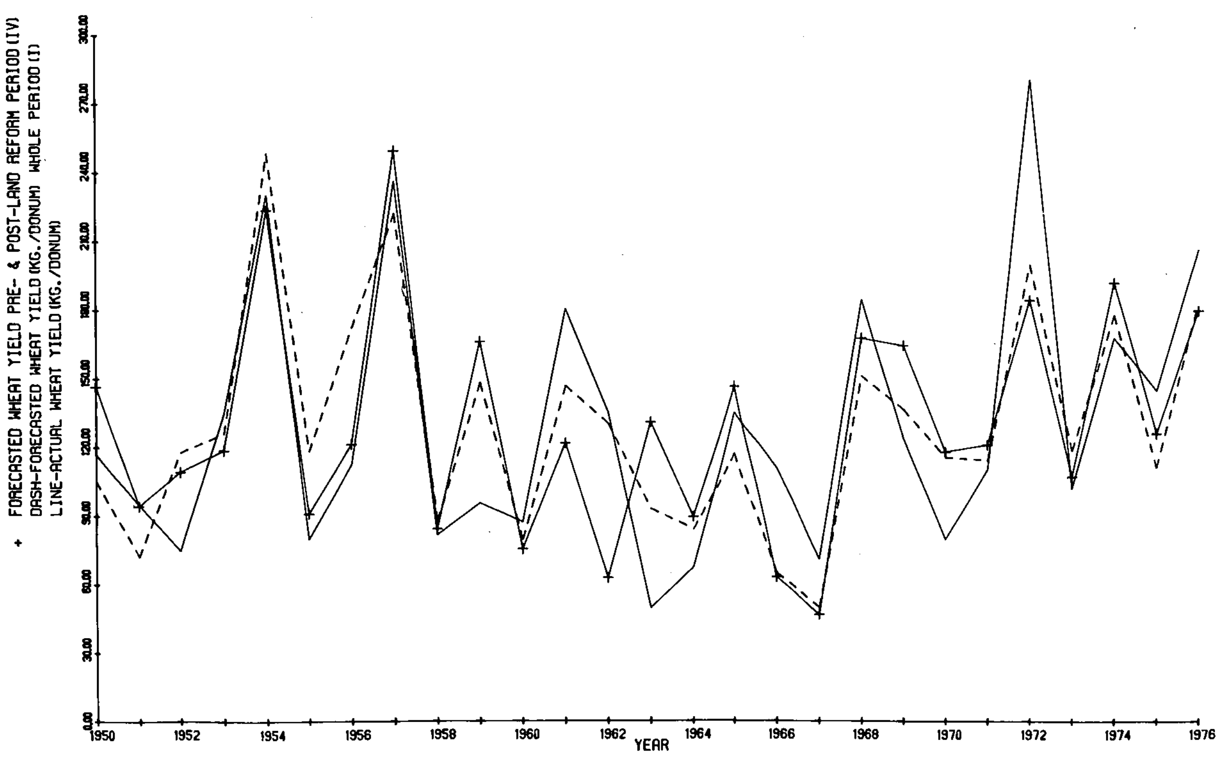


FIG. 12.3 ACTUAL & FORECASTED WHEAT YIELDS IN NINEVEH & KIRKUK PROVINCES



KIRKUK



and thirdly, a combination of the pre-and post-land reform periods (1949/50-1957/58, 1963/64 - 1975/76).

The main purposes of this study can be summarised as follows:-

1. Studying the effect of certain weather variables on cereal yield for all periods.

2. Assessing whether there was any statistical evidence for improvement in the farming system or farming practice in this region after the land reform of 1958.

3. Assessing whether there was a period of dislocation which immediately followed the implementation of the land reform. This was shown by excluding a five year period between 1958/59-1962/63 from the whole period. This five year period was selected on the basis of a decline in the cultivated area, assuming that there was no change in other factors.

4. Developing an early wheat forecasting system by using climatological data. Such early forecasts would be very useful in making policy decisions, for example, import and export, pricing, storage facilities, transport,etc.

5. Studying the possibilities of introducing HYV's into the rainfed area, and analysing the success of HYV's.

It was clear from previous chapters that there was no indication of any intensive use of new technology such as HYV's, fertilizers or other chemical plants protection during the whole period under study. The only new technology, which it seems was improved, was mechanization in order to expand the cultivated area. Here we may assume that any fluctuation in the production resulted from area and yield fluctuation, and that the latter were influenced by weather factors. Although weather may indirectly influence the size of area under production this was excluded from this study (see Fig. 1.1).

Data availability and accuracy is one of the critical factors limiting the methodology of this analysis. A continuous time series of data for a long period is only available for a limited number of meteorological stations in this area. Nonetheless,data concerning three primary weather factors could be used. These factors are rainfall (monthly and total), air temperature and relative humidity. Wheat yield is used as an agricultural variable.

Although the relationship between yield of a particular crop and weather variable is very complex, a relatively simple analysis can be made by using correlation and regression techniques.

The first distinct point appearing from this study is that the relationship between wheat yield and total rainfall in regions of high relief amplitude (600 and over), in Arbil and Sulaimaniya provinces, where minor cereal growing zones exist and high rainfall occurs, is not very significant. This does not mean that rainfall is not important, and probably the main reason for that lack of significance is the effect of other variables such as rainfall distribution, soil conditions, soil moisture and relative humidity. In addition, it seems that the location of meteorological stations does not well represent the actual environmental conditions of wheat growing because of the heterogeneity of micro-climate conditions.

A low relation between wheat yield and rainfall was also observed in another study.[40] Hooker suggested that the relation between yield and rainfall is not linear above a certain level of rainfall.[41] Furthermore, one may suggest that an improvement in agroclimatology is highly desirable in this region since it would help, for example, to establish agricultural production zones which would have many economic advantages.

In the foothill region of Kirkuk and Nineveh provinces, where total rainfall is less than in the upland region, the relation between wheat yield and total rainfall is more significant, especially during the pre-land reform period. This suggests two points. First, this may show domination of environmental conditions in general and rainfall in particular on agricultural production in this region during this period. Secondly, it also shows that in the post-land reform period, wheat yield was less affected by rainfall probably as the result of improvement in other factors, mechanization in particular.

Having discussed the effect of total rainfall on wheat yield, one must not underestimate the importance of rainfall distribution during the growing season and its effect on wheat yield. This analysis may benefit farmers in the timing of their farming operations, such as sowing, fertilizing, etc. so as to use best the periods when rainfall is most effective. In addition, the effect of rainfall distribution could provide a good deal of information to formulate irrigation policy (supplementary or necessary). This also will help to optimise water usage in agriculture.

The distribution of rainfall during the growing season tends to be more important than total rainfall. This study reveals that early rainfall during November and probably December is very important. The effect of early rainfall on the final wheat yield is positive in most cases, and the main reason for this is that rainfall is vital during the germination period during these months. Late rainfall during April and March also tends to affect the final wheat yield because it coincides with the active growth period, whilst January and February have less effect on wheat yield. May rainfall shows some negative and positive effects on wheat yield because of the type and timing of rainfall which occurs during this month (see pp.477-483).

The second weather factor is air temperature, here measured in four ways: first, average monthly maximum temperature, secondly, average monthly minimum temperature, thirdly, average monthly mean temperature and fourthly, average seasonal mean temperature for each of the three previous forms.

Generally speaking, the effect of air temperature on the final wheat yield is negative as could be expected given the semi-arid conditions of this region. Any increase in temperature can affect plants directly or indirectly through influencing the availability of soil moisture. It seems that average monthly maximum temperature is statistically more significant than other measurements, especially at the beginning of the growing season. The effect of November temperature is negative on wheat yield for the reasons mentioned above.

Temperatures may become less important during January and February; this can be explained by the fact that winter wheat can survive low temperatures. During the active growth period, April and March temperature, especially maximum temperature tends to affect wheat yield negatively.

Relative humidity tends to affect wheat yield positively during the active growth period of March and April and even in some cases, May. This is probably due to the high water requirement of plants during this period and the absorption of water directly from the air through the leaves, as well as the association between humidity and water availability in the root zone.

In addition to increased mechanization, there is one type of new technology which is relevant to trends in wheat yields, namely the introduction of HYV's. Data on wheat yield for two wheat HYV's (Mexipak and Sentor) has been obtained from three experimental farms in the rainfed area. Other information on management, application of fertilizers (chemical and manure), herbicides and pesticides and irrigation is not available; whilst it is clear that permanent irrigation was not employed at these stations, there is no evidence to suggest whether technical inputs have been used or not. Nonetheless, the original data shows there were very sharp fluctuations in the yield of HYV's within the experimental farms both from season to season, and between the farms (see Tables 7.5 and 7.6).

Regression techniques have been used to study the effect of total rainfall on HYV's wheat yield. The results of these regression functions can be seen in Table 12.15, and show apparently that total rainfall negatively affects HYV's on Mosul and Bakrajo experimental farms. In other words, any increase in rainfall decreases HYV's yield. Only the Telafar experimental farm data show rainfall having positive effects.

Since there is little difference between average rainfall in Mosul and Telafar stations (see Table 11.14), it is surprising to see total rainfall has a negative effect on wheat yield at Mosul station unless we assume there are other factors affecting yields at Mosul. The same point can be made for Bakrajo.

The regression function of wheat HYV's and total rainfall (function No.3 and 4) in Telafar experimental farm shows a good response as shown in Fig. 12.4. In fact, introducing high yield varieties may increase wheat yield response by more than three fold.

The wider introduction of HYV's into the rainfed area might, therefore, create serious problems associated with the high fluctuation in the yield as the result of rainfall fluctuation. Therefore to secure minimum yield fluctuation the following measures can be recommended:-

(1) HYV's should be restricted to rainfed areas where the average rainfall is above certain minimal levels established by the developing agency. Cultivating HYV's in low rainfall areas will only increase wide yield fluctuation from one season to another.

(2) Traditional or local varieties should be cultivated in areas where rainfall is not sufficient for HYV's.

(3) The potential yield of HYV's will not be achieved without a full input package of fertilizers, herbicides and pesticides, extension services

Table 12.15 Regression of HYV's of Wheat on Total Rainfall at Three Experimental Farms in the Rainfed Area

No.	Function	No. of cases	r	r^2	S.E.	F
	Mosul Experimental Farm					
1	Y_M = 1325.1 - .87826 TR (1.54)	7	.57	.32	181.81	2.38
2	Y_S = 648.34 - .68813 TR (1.46)	7	.55	.30	150.26	2.12
	Talafar Experimental Farm					
3	Y_M = -184.37 + 1.3942 TR (2.77)	8	.75	.56	167.86	7.68
4	Y_S = -235.72 + 1.2471 TR (5.93)	5	.96	.92	53.48	35.15
	Bakrajo Experimental Farm					
5	Y_M = 985.21 - .36910 TR (1.32)	5	.61	.37	78.75	1.74
	Y_S = 808.62 - .3456 TR (1.07)	5	.53	.28	89.70	1.18

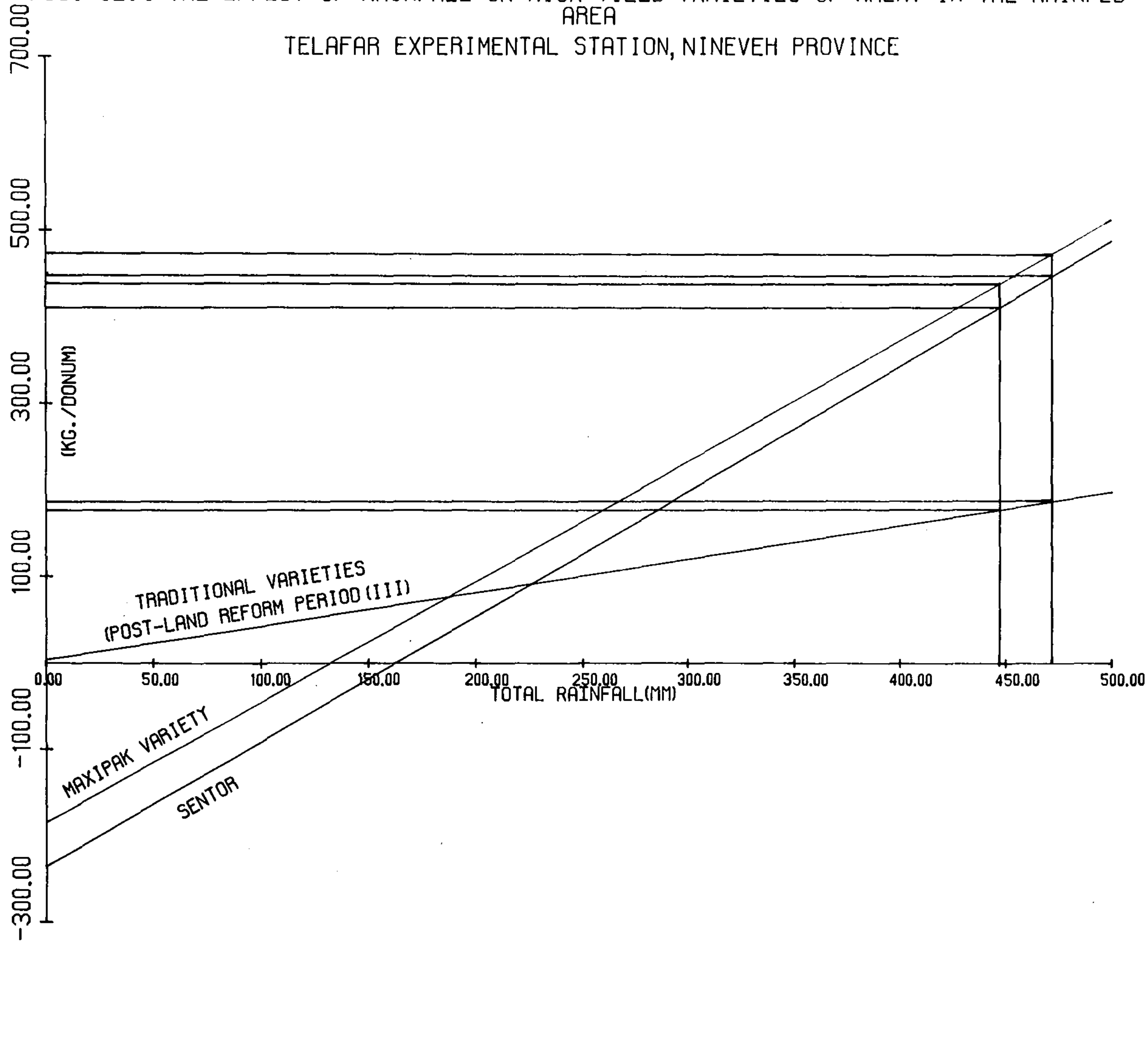
Value in Brackets is the t-value for significance tests

M = Yield Maxipak variety (kg./donum).

S = Yield Sentor variety (kg./donum).

TR = Total Rainfall.

FIG. 12.4 THE EFFECT OF RAINFALL ON HIGH YIELD VARIETIES OF WHEAT IN THE RAINFED AREA
TELAFAR EXPERIMENTAL STATION, NINEVEH PROVINCE



machinery, etc. The introduction of such an input package will depend upon market price and farmers' willingness to invest in agriculture in the case of the private sector, or on government policy in the case of state and collective farms.

(4) Farming practice should be developed from the present simple dry-fallow farming to technically advanced dry farming by using not only crop rotations, such as fodder and cereals, but also by adopting systems which help to preserve soil moisture during the long summer period. Good dry farming practice will improve wheat yield substantially, as in the case of the USA and Australia, both with HYV's and local varieties.

(5) Cereal cultivation should not be expanded to areas where annual average rainfall is below 240 m., as recommended by UNESCO (see page 437), unless supplementary irrigation systems are available. Otherwise low and very fluctuating wheat yield will be maintained. Areas with rainfall below 240 mm. should be developed for livestock grazing.

The evaluation of a wheat forecasting system in the rainfed area, based on climatological observation, showed that regression function of wheat yield and rainfall are not significant in most cases in the upland region of Arbil, Sulaimaniya and the northern part of Nineveh province. Accurate wheat yield forecasts cannot be made without further field studies on weather-crop relationships in this region.

Wheat yield forecasting is, however, possible for Nineveh and Kirkuk provinces which produced about 80 per cent of rainfed area wheat. Several forecasting formulae have been developed according to the type of climatological data and the selected period of study. In addition to these functions, other functions are built up by using a combination of certain weather variables. These functions produce more accurate results than any of the previous ones and can be used for future agricultural development.

To test this assertion the regression functions shown in Tables 12.13 and 12.4 were used to forecast the hypothetical yields of wheat between 1950 and 1975. In Fig. 12.3 the results of, first, using regression functions for Period I, the whole period and, secondly, Period IV, the combined pre- and post-land reform periods, are plotted against actual reported yields.

Two striking points emerge. First, is the very close correspondence between both forecast and actual yields, with the forecast based on Period IV functions being marginally superior in this respect. Secondly, and providing very clear justification for the necessity of isolating the period between 1958/59 and 1962/63 as a period of post land reform farming dislocation, we see that during these five years the actual yields are totally at variance with the forecasts.

Finally, one may sum up this chapter by saying that total annual rainfall is still a very important factor affecting wheat yield production in the foothill region, in particular, and the whole rainfed area in general. November, March and April rainfall is crucial in affecting wheat yield. Maximum temperature tends to negatively affect wheat yield. Relative humidity is more important at the end of the growing season.

In the following chapter, the effect of weather factors on barley yield will be examined using the same procedures as in the case of wheat.

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CHAPTER THIRTEEN

WEATHER-CROP STUDIES IN IRAQ

(Barley as a Case Study)

13.1 Introduction

In the previous chapter weather-crop relationships in the rainfed region of Iraq were studied taking wheat as the first example. In this chapter barley is taken as a second case study, the same weather variables being used.

Whilst regression analysis of barley yields during the period 1949/50 to 1975/76 indicates a negative trend, i.e. yields decline, none of the regression functions was significant from the statistical point of view (the F-values for the regression functions are very low). We can assume therefore that for our purposes there is no significant trend change in yield (see Table 11. 19).

We have the same objectives and adopt the same analytical procedures as in the study of wheat.

13.2 The Correlation Between Barley Yield and Total Rainfall

The correlation between barley yield and total rainfall tends to follow the same pattern as in the case of wheat yield. Table 13.1 shows the correlation between barley yield and total rainfall for the whole Period I, 1949/50 - 1975/76. It is clear from this table that the correlation between barley yield and total rainfall is positively significant in all foothill stations : Sinjar, Mosul, Telafar, Kirkuk, Hawija Project, Iftikhar and Tuz-Khurmatu, in Nineveh and Kirkuk provinces. The correlation between barley yield and total rainfall is also positively significant in three upland stations in Nineveh province. Only one station in Arbil province shows a significant correlation between barley yield and total rainfall. None of the stations in Sulaimaniya province show a significant correlation between barley yield and total rainfall.

The reasons for the low correlation between barley yield and total rainfall in the upland stations are generally the same as those advanced in our study of wheat yields (see page 468).

For the pre-land reform Period II, 1949/50-1957/58 , the correlation between barley yield and total rainfall is significant for fewer stations than in the case of the whole period as can be seen from Table 13.2 Here, total rainfall is significantly correlated with barley yield at three foothill stations- Sinjar, Mosul and Telafar, and two upland stations - Dohuk and Amadiya in Nineveh province.

Total rainfall is significantly and positively correlated with barley yield in one foothill station in Kirkuk province, and there is also one upland station in Arbil which shows a very significant and positive correlation between barley yield and total rainfall. But, the number of case-years is very small, so the accuracy of such results must be treated with caution. None of the upland stations in Sulaimaniya province shows a significant correlation between barley yield and total rainfall.

The post-land reform Period III shows the same pattern of correlation between barley yield and total rainfall as in the previous period and the whole period. Table 13.3 reveals that barley yield is significantly and positively correlated with total rainfall at three foothill stations - Mosul, Sinjar and Telafar, and at two upland stations - Aqra and Zakho, in Nineveh province.

Two stations in Kirkuk province show a significant and positive correlation between barley yield and total rainfall. These stations are Kirkuk and Hawija. One station, Iftikhar, shows insignificant negative correlation, and the fourth station which shows insignificant positive correlation is Tuz-Khurmatu. None of the upland stations in Arbil and Sulaimaniya provinces shows a significant correlation between barley yield and total rainfall, regardless of the sign of the correlation coefficients.

The 22-year Period IV shows the same type of correlation between barley yield and total rainfall as the whole Period I. Table 13.4 shows that the correlation between barley yield and total rainfall is significantly positive in most foothill stations - Sinjar, Mosul, Telafar, Kirkuk, Hawija Project and Tuz-Khurmatu . Only four upland stations, Aqra, Dohuk, Zakho and Rawanduz, show significant correlation between barley yield and total rainfall. None of the other stations shows a significant correlation.

13.3 The Correlation Between Barley Yield and Monthly Rainfall

An analysis of the whole period shows that October rainfall is negatively correlated with barley yield in all stations except four (see Table 13.1). These stations are Sinjar, Telafar, Tuz-Khurmatu and Chwarta. But none of these correlations are significant from the statistical point of view. The reasons for this are the same as those advanced for wheat (see pp. 472).

November rainfall is positively correlated with barley yield except in Arbil station, as can be seen in Table 13.1. Only four upland stations show significant and positive correlation coefficients. These stations are Aqra, Bakrajo, Penjwin and Chwarta. But, as mentioned before, these stations, especially Penjwin and Chwarta, have a small number of cases (years) which means that the accuracy of such results must be approached with caution.

The correlation between barley yield and November rainfall is not as significant as in the case of wheat yield. The reasons for this are considered later (see pp. 538).

December rainfall is positively correlated with barley yield at all stations in Nineveh and Kirkuk provinces. Only three stations, however, show significant correlation coefficients. These stations are Sinjar, Telafar and Aqra. The correlation between December rainfall and barley yield at all stations in Arbil and Sulaimaniya provinces except two, is negative and insignificant (see Table 13.1).

January rainfall is positively correlated with barley yield at all stations in Nineveh, Kirkuk and Arbil provinces, except Iftikhar which shows a negative correlation coefficient. Only Sinjar and Aqra stations in Nineveh province have significant correlation coefficients. The correlation coefficients between barley yield and January rainfall are insignificantly negative at all stations in Sulaimaniya province.

The correlation between February rainfall and barley yield is significantly positive at Shaqlawa station in Arbil province. The rest of the stations show insignificant positive correlation coefficients (see Table 13.1).

It appears from Table 13.1, however, that March rainfall is of some importance to barley yield. The number of stations which have a significant correlation between barley yield and March rainfall has increased, particularly in the foothill stations in Nineveh and Kirkuk provinces. Stations in Arbil and Sulaimaniya provinces show positive and insignificant correlation between barley yield and March rainfall, except Salahuddin station which shows a very low negative correlation coefficient.

April rainfall seems also important to barley yield. As can be seen from Table 13.1, the foothill stations of Nineveh and Kirkuk provinces show a significant and positive correlation between barley yield and April rainfall. Three stations in Arbil province show insignificant negative correlation between barley yield and April rainfall. As for the rest of the stations, the correlation coefficients are insignificantly positive.

Generally speaking, as in the case of wheat yield, March and April rainfall is very important in determining the final barley yield, this because of the high demand of water by the plant during this active growth period. Any shortage of water during these two months affects the final yield negatively. May rainfall, on the other hand, shows more insignificant negative than positive correlations with barley yield (see Table 13.1). This also is logical if we consider the stage of the plant growth during this month. It is clear from Table 13.1 that May rainfall is negatively correlated with barley yield at all stations except Aqra, in Nineveh and Sulaimaniya provinces, whilst the correlation coefficients are positive at all stations except Tuz-Khurmatu, in Kirkuk and Arbil provinces.

The question appears why are barley yields not significantly correlated with early rainfall? From observation of the farming practice we know that there are significant variations in the timing of barley sowing. All farmers who grow barley will always sow a minimal area hopefully to ensure a base-level production for animal feed; this is made possible by the crop's relative low vulnerability to water shortage. The date of sowing, however, can be delayed if early rainfall (November and December) is low since barley has a relatively short growing season.

Farmers may also be faced with a choice between sowing wheat or barley. Wheat is more vulnerable to water shortages and has a longer growing season, but gives better cash returns. The result appears to be that if early rainfall promises well for wheat farmers will expand the area under that crop; if it does not farmers may, after some delay, sow more barley.

The aggregate seasonal statistical result indicates that the area under wheat fluctuates more than that under barley. At the beginning of the season farmers have some latitude in choice not only of crop but of timing and the result seems to be a lessening of the direct correlation between early rainfall and barley yield. Given the base-level fodder demand for barley the areal fluctuation is lower than for wheat (see Table 11.5).

In the pre-land reform Period II October, November, December, January and February rainfall are not significantly correlated with barley yield, except at a few stations (see Table 13.2). March rainfall is significantly correlated with barley yield at all stations except two, in Nineveh province. Also, two stations in Kirkuk province and one in Arbil province show a significant and positive correlation between March rainfall and barley yield, whilst other stations show no significant correlation at all (see Table 13.2). April rainfall is significantly correlated with barley yield at two stations in Nineveh province, four stations in Kirkuk province and two stations in Sulaimaniya province (see Table 13.2). May rainfall is not significantly correlated with barley yield regardless of the sign of the correlation coefficients (see Table 13.2).

In the post-land reform Period III, Table 13.3 shows that October rainfall is negatively correlated with barley yield in all stations except three. Arbil station shows a significant and negative correlation between barley yield and October rainfall. Table 13.3 also shows that November rainfall is not significantly correlated with barley yield. December rainfall is significantly correlated with barley yield in four stations in Nineveh province and one station in Arbil province, as can be seen from Table 13.3. January and February rainfall is significantly correlated with barley yield at Sersank station in Nineveh province only (see Table 13.3). It is also clear from this table that March rainfall is significantly correlated with barley yield at two stations in Nineveh province and one station in Kirkuk province. Further, April rainfall appears significantly correlated with barley yield at two stations in Nineveh province. May rainfall shows a significant correlation with barley yield at three stations in Kirkuk province. This would be caused by the same factors considered in relation to wheat (see page 483).

The correlation between barley yield and monthly rainfall for the 22-year Period IV follows the same pattern as for the whole Period I (see Table 13.4). October rainfall is negatively correlated with barley yield at more stations, and none of these correlation coefficients are significant. November rainfall is positively and significantly correlated with barley yeild at one station in Nineveh province and four stations in Sulaimaniya province (see Table 13.4). December rainfall is significantly and positively correlated at three stations in Nineveh province and one station in

Sulaimaniya province (see Table 13.4).

January rainfall is significantly and positively correlated with barley yield at one station in Nineveh province. February rainfall, however, is not significantly correlated with barley yield, and also it is clear that March rainfall is significantly correlated with barley yield at any station except Dohuk, in Nineveh province (see Table 13.4). This table also shows that barley yield is significantly correlated with March rainfall at three stations out of four in Kirkuk province, whilst there is no significant correlation between March rainfall and barley yield at any station in Arbil and Sulaimaniya provinces. Two stations in Nineveh province show a positive and significant correlation coefficient between April rainfall and barley yield (see Table 13.4). In Kirkuk province, three stations show significant correlation coefficient between April rainfall and barley yield. Two stations in Sulaimaniya province show a positive and significant correlation between barley yield and April rainfall. Table 13.4 shows that May rainfall is significantly and positively correlated with barley yield at one station in Arbil province, whilst in other stations May rainfall is not significantly correlated with barley yield regardless of the sign of the correlation coefficients (see pp.477-483).

Generally speaking, the results of this analysis can be summarized as follows. First, early rainfall is not as significantly correlated with barley yield as in the case of wheat yield, probably due to the fact that barley sowing may be delayed as late as December and January. Secondly, late rainfall during March and April is very important to the final yield. Rainfall during these two months show more significant correlation with barley yield than any other months of the growing season. This is due to the fact that the plant requirement of water is very high during the period of active growth. Thirdly, May rainfall shows, in general, more negative correlation coefficients with barley yield.

Table 13.1 The Correlation Between Barley Yield and Monthly and Total Rainfall in the Rainfed Area for Period I, 1949/50-1975/76

	No. of cases	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	Tot. Rain-fall
Nineveh										
Sinjar	27	.035	.285	.457*	.413*	.128	.479*	.617**	-.129	.634**
Mosul	27	-.006	.249	.347	.247	.071	.589**	.498**	-.163	.605**
Telafar	27	.015	.252	.462*	.267	.226	.494**	.272	-.112	.609**
Aqra	20	-.058	.462*	.586**	.509*	.012	.611**	.317	.155	.679*
Sersank	20	-.253	.333	.063	.384	.420	.488**	.222	-.103	.416
Dohuk	20	-.179	.381	.259	.346	.212	.279	.502*	-.188	.585**
Amadiya	18	-.207	.267	.135	.239	.151	.581*	.093	-.037	.355
Zakho	13	-.050	.109	.328	.190	.468	.846**	.421	-.079	.767**
Kirkuk										
Kirkuk	27	-.218	.168	.127	.103	.137	.503**	.398*	.064	.606**
Hawija	27	-.303	.042	.071	.209	.133	.647**	.335	.088	.593*
Iftikhar	21	-.338	.184	.030	-.081	.283	.293	.548*	.089	.461*
Tuz-Khur-matu	21	.191	.150	.033	.050	.325	.453*	.582**	-.041	.504*
Arbil										
Shaqlawa	27	-.219	.179	.095	.048	.398*	.098	.058	.178	.255
Arbil	23	-.396	-.248	-.161	.003	.307	.106	-.114	.218	.035
Rawnduz	22	-.166	.263	.394	.122	.297	.356	-.088	.128	.434*
Salahuddin	21	-.194	.152	-.025	.167	.105	-.007	-.271	.317	.104
Sulaimaniya										
Dokan	26	-.354	.258	-.024	-.201	.146	.220	.198	-.187	.120
Sulaimaniya	23	-.201	.408	-.146	-.406	.160	.138	.187	-.344	.033
Halabja	19	-.069	.314	-.220	-.299	.189	.231	.237	-.291	.033
Bakrajo	20	-.217	.512*	-.047	-.382	.012	.275	.312	-.318	.109
Penjwin	12	-.019	.781**	-.488	-.163	.002	.389	.491	-.276	.325
Chwarta	11	.237	.765**	-.327	-.280	.320	.410	.590	-.202	.541

* Significant at 5% level

** " 1% "

Table 13.2 The Correlation Between Barley Yield and Monthly and Total Rainfall in The Rainfed Area for Period II, 1949/50 - 1957/58

	No.of cases	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Tot. Rain-fall
Nineveh										
Sinjar	9	.317	.240	-.020	.265	.266	.750*	.796	.065	.687*
Mosul	9	-.103	.233	.216	-.026	.180	.837**	.660*	.029	.668*
Telafar	9	.496	-. 09	.039	.130	.095	.804**	.660*	-.376	.790**
Aqra	6	.060	.793	.836*	.947**	.058	.783	.500	.350	.777
Sersank	9	-.322	.368	-.402	.038	.279	.490	.543	-.087	.278
Dohuk	8	-.104	.470	-.178	.474	.330	.878**	.473	-.351	.760*
Amadiya	8	-.306	.456	-.408	.457	.450	.827*	.619	-.169	.899*
Zakho	7	-.041	.367	-.153	-.055	.584	.896**	.718	-.280	.707
Kirkuk										
Kirkuk	9	-.099	.312	-.126	-.274	.472	.843**	.700*	.068	.701*
Hawija	9	-.463	-.171	-.152	-.147	.420	.707*	.687*	.045	.609
Iftikhar	9	-.193	-.019	-.187	-.187	.670*	.391	.854**	.106	.573
Tuz-Khur-matu	7	-.476	.371	-.300	-.148	.639	.506	.834*	.065	.619
Arbil										
Shaqlawa	9	.025	.329	.141	.155	.399	.641	.096	.049	.515
Arbil	9	-.141	-.281	.071	.067	.282	.706*	.364	.113	.447
Rawnduz	9	.038	.245	.532	.251	.267	.493	.222	.130	.588
Salahuddin	4	-.236	.208	.036	.165	.415	.899	.070	.524	.976*
Sulaimaniya										
Dokan	8	-.512	.193	-.237	-.427	.144	.381	.618	-.216	.127
Sulaimaniya	8	-.237	.718*	-.233	-.476	.358	.268	.585	.039	.331
Halabja	9	.703*	.824**	-.445	-.180	.320	.375	.695*	-.260	.506
Bakrajo	6	-.350	.683	-.476	-.363	.211	.433	.397	-.165	.244
Penjwin	9	-.042	.796**	-.732*	-.212	-.053	.393	.572	-.310	.310
Chwarta	7	.413	.944**	-.531	-.362	.330	.468	.804*	-.215	.562

* Significant at 5% level

** " 1% "

Table 13.3 The Correlation Between Barley Yield and Monthly and Total Rainfall for the Post-land Reform Period III, 1963/64 - 1975/76

	No. of cases	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Tot. Rainfall
Nineveh										
Sinjar	13	-.007	.173	.842**	.536	-.020	.455	.782**	-.126	.820**
Mosul	13	.034	.299	.516	.325	-.106	.673*	.580*	-.068	.812**
Telafar	13	-.064	.514	.770**	.415	.439	.289	.321	.489	.890**
Aqra	13	-.144	.488	.665*	.286	.006	.519	.381	.458	.756**
Sersank	7	-.311	.367	.740	.851*	.768*	.590	-.182	.593	.667
Dohuk	7	-.272	.513	.866*	.384	-.489	.327	.622	.401	.739
Amadiya	8	.594	-.199	.331	.299	-.327	.567	.046	.162	.374
Zakho	6	-.235	-.312	.765	.399	.630	.972**	.203	.526	.904*
Kirkuk										
Kirkuk	13	-.293	.094	.334	.445	-.149	.321	.294	.587*	.684**
Hawija	13	-.392	.164	.232	.532	-.293	.621*	.303	.683**	.787**
Iftikhar	7	-.627	.353	-.661	-.148	-.428	-.271	.208	.906**	-.214
Tuz-Khurmatu	10	.549	.141	.291	.170	-.104	.366	.301	.627	.506
Arbil										
Shaqlawa	13	-.273	.189	.205	.143	.413	-.009	-.120	.413	.335
Arbil	13	-.581*	-.131	-.265	-.024	.405	-.088	-.250	.522	-.106
Rawanduz	8	-.311	.350	.791*	.453	.228	-.103	.412	.587	.595
Salahuddin	12	-.215	.359	-.116	.160	.153	-.467	-.307	.330	-.113
Sulaimaniya										
Dokan	13	-.469	.396	.180	.005	.286	-.249	.223	.397	.325
Sulaimaniya	10	-.481	.165	-.258	-.209	.522	.221	.060	-.145	.148
Halabja	5	.017	.064	-.592	.377	-.003	.567	.550	.361	.288
Bakrajo	9	-.420	.508	-.226	.133	-.409	.028	.314	.357	.144
Penjwin+										
Chwarta+										

* Significant at 5% level

** " 1% "

\+ Few Number of cases

Table 13.4 The Correlation Between Barley Yield and Monthly and Total Rainfall for the 22-year Period IV, 1949/50 - 1957/58, 1963/64 - 1975/76

	No. of cases	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Tot. Rainfall
Nineveh										
Sinjar	22	.035	.193	.458*	.403	.173	.590**	.776**	-.006	.747**
Mosul	22	-.031	.224	.377	.188	.087	.743**	.608**	-.001	.736**
Telafar	22	-.009	.245	.449*	.250	.273	.600**	.388	.058	.725**
Aqra	19	-.078	.456*	.615**	.557**	.026	.607**	.391	.401	.758**
Sersank	16	-.282	.330	.027	.359	.395	.490*	.174	-.030	.390
Dohuk	15	-.210	.341	.263	.338	.179	.338	.497	-.194	.591*
Amadiya	16	-.137	.270	.124	-.298	.168	.584*	.178	-.065	.402
Zakho	13	-.050	.109	.328	.190	.468	.846**	.421	-.080	.767**
Kirkuk										
Kirkuk	22	-.229	.146	.074	.078	.139	.526*	.426*	.249	.644**
Hawija	22	-.401	.003	.021	.199	.130	.671**	.372	.212	.632**
Iftikhar	16	-.386	.135	-.051	-.162	.286	.290	.625**	.288	.465
Tuz-Khurmatu	17	.219	.353	.011	.044	.414	.495*	.651**	.212	.618**
Arbil										
Shaqlawa	22	-.284	.160	.074	.138	.412	.107	.077	.205	.281
Arbil	22	-.397	-.249	-.164	-.004	.332	.107	-.117	.218	.035
Rawnduz	17	-.153	.237	.446	.295	.311	.352	.144	.274	.558*
Salahuddin	16	-.221	.249	-.116	.177	.161	.014	-.248	.492*	.127
Sulaimaniya										
Dokan	21	-.424	.280	-.054	-.251	.277	.223	.261	.072	.212
Sulaimaniya	18	-.267	.539*	-.201	-.389	.330	.163	.257	-.059	.180
Halabja	14	-.081	.492	-.319	-.235	.247	.269	.577*	-.058	.232
Bakrajo	15	-.335	.634*	-.057	-.357	.185	.360	.387	-.117	.265
Penjwin	9	-.042	.796**	.732*	-.212	-.053	.393	.572	-.310	.310
Chwarta	7	.413	.944**	-.531	-.362	.332	.468	.804*	-.215	.562

* Significant at 5% level

** " 1% "

13.4 The Correlation Between Barley Yield and Air Temperature

Data on air temperature are adequately available only for two stations in the rainfed area of northern Iraq, viz. Mosul and Kirkuk. Four sets of correlation analysis have been calculated between barley yield and first, average monthly maximum temperature; second, average monthly minimum temperature; third, average monthly mean temperature and fourth, average minimum, maximum and mean seasonal temperatures. The correlation between barley yield and each of these average temperatures is discussed in the following sections.

13.4.1 The Correlation Between Barley Yield and Average Monthly Maximum Temperature

Generally speaking, the correlation between barley yield and average monthly maximum temperature is negative, except in October as can be seen from Table 13.5. This relationship between barley yield and average monthly maximum temperature is identical with that found in the wheat case study, (see page 484).

An examination of the significance of these correlation coefficients reveals that average November maximum temperature is significantly and negatively correlated with barley yield at Mosul and Kirkuk stations for the whole period. At Kirkuk station, average November maximum temperature is also significantly and negatively correlated with barley yield for two Periods, II and IV (see Table 13.5). The correlation between March maximum temperature and barley yield is negatively significant at Mosul station for Period IV only, whilst April maximum temperature is significantly and negatively correlated with barley yield at Kirkuk station during the pre-land reform period.

Examining, however, the correlation between barley yield and average monthly maximum temperature, regardless of the significance of the correlation, shows that the correlation coefficients are high at the beginning of the growing season (November and December), decrease during January and February and increase again during March and April. The correlation between average October and May maximum temperature is very low. The reasons for such a pattern of correlation between barley yield and average monthly maximum temperature are similar to those already noted for wheat (see pp. 485). In addition, it seems from Table 13.5 that barley yield is less affected by maximum temperature than wheat yield.

13.4.2 The Correlation Between Barley Yield and Average Monthly Minimum Temperature

As in the case of wheat yield, the effect of average monthly minimum temperature is less important than the average monthly maximum temperature. Table 13.6 shows that average May minimum temperature is significantly and negatively correlated with barley yield both in the whole period and in the 22-year period at Mosul station. Average November and April minimum temperature is significantly and negatively correlated with barley yield in the pre-land reform period at Kirkuk station. The reasons for such low impact of the average monthly minimum temperature have been already explained in the previous chapter (see page 487).

Table 13.5 The Correlation Between Barley Yield and Average Monthly Maximum Temperature in the Rainfed Area

Station / Period	Mosul I	Mosul II	Mosul III	Mosul IV	Kirkuk I	Kirkuk II	Kirkuk III	Kirkuk IV
No. of cases	27	9	13	22	27	9	13	22
October	.079	.191	-.069	.081	.224	.418	.054	.250
November	-.429*	-.618	-.252	-.393	-.502**	-.669**	-.411	-.516*
December	-.337	-.427	-.347	-.360	-.203	-.271	-.084	-.178
January	-.233	-.121	-.290	-.200	-.094	-.090	.016	-.030
February	-.126	-.254	-.178	-.196	-.185	-.116	-.198	-.133
March	-.254	-.655	-.426	-.571**	-.256	-.361	-.273	-.352
April	-.342	-.532	-.251	-.357	-.358	-.857**	-.115	-.382
May	-.054	-.306	-.067	-.046	-.144	-.083	-.390	-.190
Seasonal Av.Max. Temp.	-.428*	-.669*	-.482	-.511*	-.449*	-.551	-.362	.459*

* Significant at 5% level
** " 1% "

Sources : Our Calculation

Table 13.6 The Correlation Between Barley Yield and Average Monthly Minimum Temperature in the Rainfed Area

Station / Period	Mosul I	Mosul II	Mosul III	Mosul IV	Kirkuk I	Kirkuk II	Kirkuk III	Kirkuk IV
No.of cases	27	9	13	22	27	9	13	22
October	-.312	-.391	-.312	-.321	.060	.356	-.083	-.074
November	-.236	-.729	-.005	-.308	-.353	-.805**	-.072	-.365
December	-.028	-.315	.210	-.070	-.193	-.584	.192	-.184
January	.092	.032	.201	.120	.035	-.068	.122	.031
February	.051	.302	-.358	-.014	-.153	.180	-.427	-.087
March	.133	-.019	.363	.119	.014	-.103	.223	-.026
April	-.175	-.406	.015	-.126	-.120	-.661*	.092	-.094
May	-.402*	-.582	-.397	-.422*	-.082	-.186	.044	-.113
Seasonal Av. Min. Temp.	-.207	-.630	-.074	-.249	-.218	-.323	.022	-.179

* Significant at 5% level
** " 1% "

13.4.3 The Correlation Between Barley Yield and Average Monthly Mean Temperature

The correlation between barley yield and average monthly mean temperature is negative as in the case of average monthly minimum and maximum temperatures. Table 13.7 shows the results of these correlations.

Generally speaking, it can be seen from this table that all the correlation coefficients at Mosul station are negative in all periods; Kirkuk station, however, shows a low positive correlation between average monthly mean temperature in some periods. Generally it seems that average November mean temperature has an important negative impact on the final yield. Average April mean temperature is significantly and negatively correlated with barley yield at Kirkuk station in the pre-land reform period. It seems, therefore, that the correlation between barley yield and average monthly mean temperature is relatively high during November and December, declines during January and February and increases during March and April.

13.4.4 The Correlation Between Barley Yield and Average Seasonal Temperature

Correlation has been calculated between barley yield and first, average seasonal maximum temperature, second, average seasonal minimum temperature, and third, average seasonal mean temperature. It seems from Tables 13.5, 13.6 and 13.7 that the average seasonal maximum temperature is more important than the other measures. Table 13.5 shows that average seasonal maximum temperature is significantly and negatively correlated with barley yield in three periods at Mosul station and two periods in Kirkuk station.

Table 13.7 The Correlation Between Barley Yield and Average Monthly Mean Temperature in the Rainfed Area

Station / Period	Mosul I	Mosul II	Mosul III	Mosul IV	Kirkuk I	Kirkuk II	Kirkuk III	Kirkuk IV
No.of cases	27	9	13	22	27	9	13	22
October	-.165	-.028	-.236	-.155	.167	.484	-.015	.188
November	-.424*	-.866**	-.174	-.424*	-.469*	-.783*	-.280	-.487
December	-.238	-.418	-.096	-.270	-.204	-.408	.056	-.181
January	-.103	-.063	-.080	-.070	-.076	-.086	.074	-.004
February	-.027	-.044	-.270	-.102	-.156	.011	-.316	-.119
March	-.140	-.486	-.006	-.298	-.140	-.255	-.032	-.212
April	-.245	-.368	-.142	-.235	-.287	-.828**	-.040	-.295
May	-.159	-.519	-.107	-.282	-.130	-.115	-.199	-.178
Seasonal Av. Mean Temp.	-.394*	-.614	-.310	-.472*	-.354	-.422	-.206	-.339

* Significant at 5% level

** " 1% "

Table 13.6 reveals that average seasonal minimum temperature is not significantly correlated with barley yield in all periods at the two stations. Moreover, average seasonal minimum temperature is insignificantly positively correlated with barley yield in the post-land reform period at Kirkuk station.

Meanwhile Table 13.7 shows that average seasonal mean temperature is significantly and negatively correlated with barley yield in two periods at Mosul station and there is no significant correlation at all at Kirkuk station.

It can be concluded from the foregoing discussion of the correlation between air temperature and barley yield that the effect of air temperature on barley yield is less significant than in the case of wheat yield. There are many reasons for this. For example, barley is less sensitive to harsh thermal conditions than is wheat, whilst late cultivation probably makes temperature less influential on final yield.

Nonetheless, it seems that temperature is negatively correlated with barley yield. Also it is clear that November and April temperature in particular may have a negative impact on the final yield. As for seasonal temperature, it seems that the average seasonal maximum temperature has shown a more significant relation than the other two seasonal averages.

13.5 The Correlation Between Barley Yield and Relative Humidity

Data on relative humidity are available only at Mosul and Kirkuk stations. Table 13.8 shows the results of computed correlations between barley yield and average monthly relative humidity. In general, relative humidity is mainly significant during March, April and May. Average March relative humidity is significantly and positively correlated with barley yield in all periods at Mosul station and in two periods at Kirkuk station. Average April relative humidity on the other hand, is significantly and positively correlated with barley yield in all periods at the two stations. Average May relative humidity is significantly and positively correlated with barley yield in three periods at Mosul station and one period at Kirkuk station. Probably the reason for the low correlation at the beginning of the season is due to the lateness of barley sowing relative to wheat. During the active growth of March and April high, plants absorb water both through roots and leaves and the latter can make relative humidity very important as a source of water.

13.6 Regression Analysis

In this second analytical approach general sets of regression functions have been built up according to different climatic variables for example total rainfall, monthly rainfall, minimum, maximum and mean temperature and finally, relative humidity. In the following sections the effect of each of these variables will be discussed separately.

13.7 The Effect of Total Rainfall on Barley Yield

As in the case of wheat yield, studying the effect of total rainfall on barley yield is considered for each province individually. Examining the results of these regressions has suggested that the effect of total rainfall on barley yield is not significant in the uplands stations of Sulaimaniya and Arbil provinces where rainfall is relatively high, except in some periods which show little effect. But one cannot rely on the accuracy of these functions because the number of cases (years) is very small. Appendix J, Table J.1 shows the results of these regressions.

Table 13.8 The Correlation Between Barley Yield and Relative Humidity in The Rainfed Area of Iraq

	Mosul I	Mosul II	Mosul III	Mosul IV	Kirkuk I	Kirkuk II	Kirkuk III	Kirkuk IV
No. of cases	27	9	13	22	27	9	13	22
October	-.045	-.197	-.185	-.126	-.293	-.349	-.298	-.291
November	.225	-.002	.235	.138	.206	-.009	.377	.164
December	.066	.005	.093	.062	.200	-.255	.430	.139
January	.336	.227	.340	.283	.145	-.481	.476	.142
February	.256	.513	.021	.255	.092	.191	-.330	.035
March	.551**	.827**	.596*	.645**	.511**	.563	.510	.545**
April	.671**	.824**	.669*	.733**	.668**	.816**	.571*	.716**
May	.389*	.458	.693**	.566**	.221	.110	.631*	.346

* Significant at 5% level

** " 1% "

Source : Our Calculation

In the following sections, the effect of total rainfall on barley will be considered in detail only in Nineveh and Kirkuk provinces.

13.7.1 The Effect of Total Rainfall on Barley Yield in Nineveh Province

As in the case of wheat, data on total rainfall is available at eight stations in this province. Appendix J, Table J.1 shows the results of this set of regressions. One of the most obvious points to appear is that total rainfall has no significant effect on barley yield at most of the upland stations of this province, and this is a similar situation to the wheat yield, or to the case of barley yield in Arbil and Sulaimaniya provinces. The reasons for such low effect have already been noted in the previous chapter (see page 494).

Since the results of the three foothill stations - Mosul, Sinjar and Telafar - are very close, one station, Telafar, has been chosen as an example to study the effect of total rainfall on barley yield. One may note that the regression functions for Telafar are not the best for all periods, but it has the additional advantage of close comparison with the wheat yield function at the same station (see Appendix J, Table J.1 for details). Table 13.9 shows the results of these regression functions for four periods at Telafar station. It can be seen from Table 13.9 the effect of total rainfall on barley yield is positive in all cases. In other words, any increase in rainfall will increase barley yield. The first function explains 37 per cent of the annual barley yield variation in this province. This function also shows that an increase of 10 mm. of rain will increase barley yield by 4.66 kg./donum above the average level. The pre-land reform function (function No.II) explains 62 per cent of the annual barley yield variation and it shows that an increase of 10 mm. of rainfall will increase barley yield by 11.6 kg./donum above the average level. It seems, as in the case of wheat yield, that rainfall dominates barley yield during the pre-land reform period (see page 495). The post-land reform function (function No. III) explains 79 per cent of the annual barley yield variation, but the coefficient of the rainfall dropped from 1.16 mm. in the pre-land reform period to .542 mm. in the post-land reform period. This means that in the pre-land reform period barley yield was even more dependent on total rainfall. Fig. 13.1 explains this situation very clearly. Therefore, the post-land reform function tends to be more accurate from the statistical point of view than any other function.

The regression function of combination of the pre- and post-land reform periods (function No. IV) explains 53 per cent of the annual barley yield variation in this province. The coefficient of rainfall shows that an increase of 10 mm. will increase barley yield by 5.85 kg/donum. This coefficient is higher than the coefficient of the post-land reform period. This is probably due to the effect of the high rainfall coefficient in the pre-land reform period which is part of the time series in this function. Comparing the effect of total rainfall on wheat and barley yields in Nineveh province reveals that barley yield responds to total rainfall more than wheat yield, as one can see from the rainfall coefficients in the regression functions for both crops (see Tables 12.9 and 13.9). Fig. 13.2 shows the response of wheat and barley yields to total rainfall for the whole period. It is clear from Fig.13.2 that barley yield responds more than wheat. This phenomenon is related to the following farming policy.

1) Farmers cultivate barley when rainfall is late or inadequate in a particular season. Although the price of wheat is higher, this choice will still provide adequate incomes to farmers.

2) Since barley is less vulnerable than wheat to water deficit, farmers may cultivate barley in more arid regions or on less productive land where there is considerable risk of severe and damaging water deficit.

As for other statistical measurements, the two sets of regression functions (Tables 12.9 and 13.9) reveal a very close correspondence in terms

Table 13.9 Regression of Barley Yield on Total Rainfall in Nineveh province (Telafar Station)

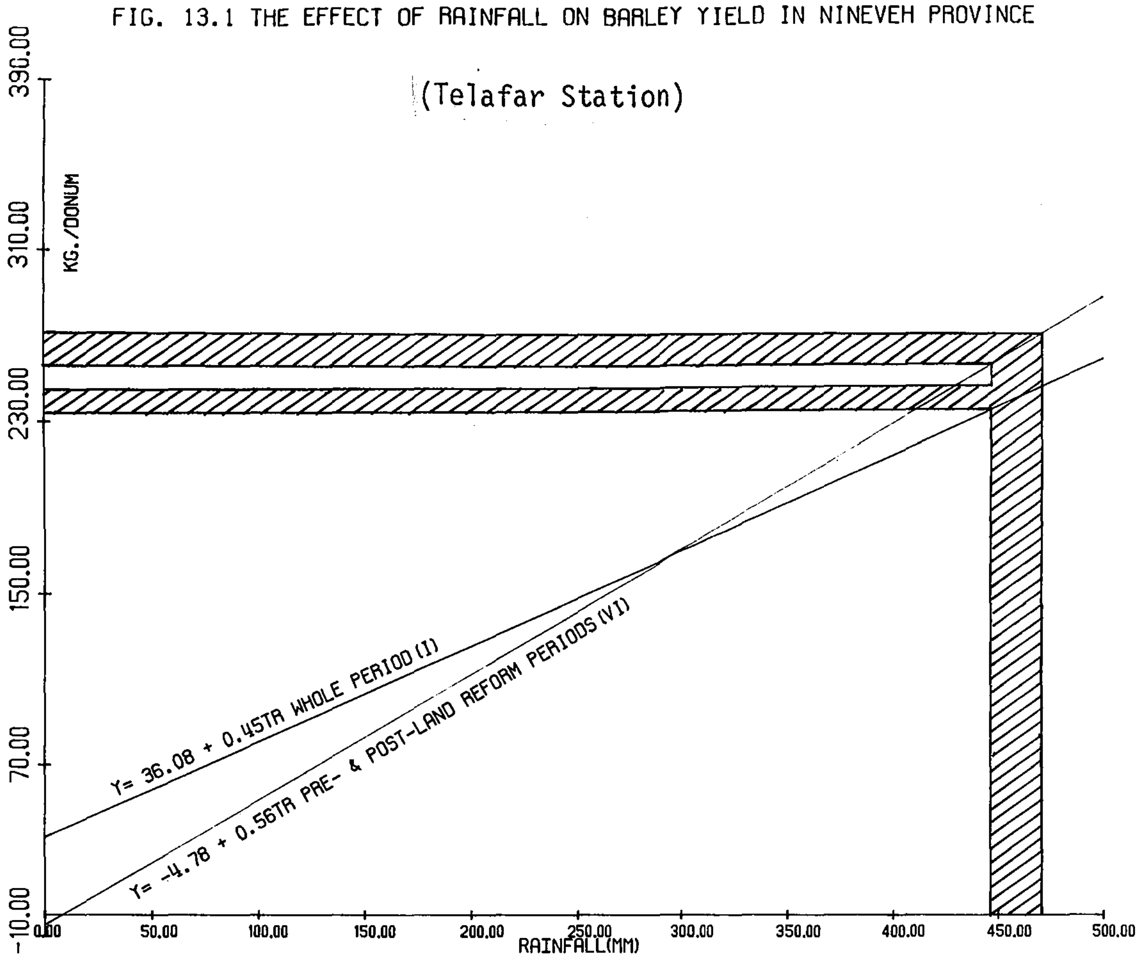
No.	Function	No. of cases	r	r^2	S.E.	F	Notes
I	Y = 36.08 + .446 TR (3.84)	27	.61	.37	69.85	14.73	Whole period
II	Y = -140.66 + 1.16 TR (3.40)	9	.79	.62	73.42	11.58	Pre-land reform period
III	Y = -11.699 + .542 TR (6.48)	13	.89	.79	37.94	42.04	Post-land reform
IV	Y = -4.78 + .585 TR (4.71)	22	.73	.53	64.98	22.14	22-year

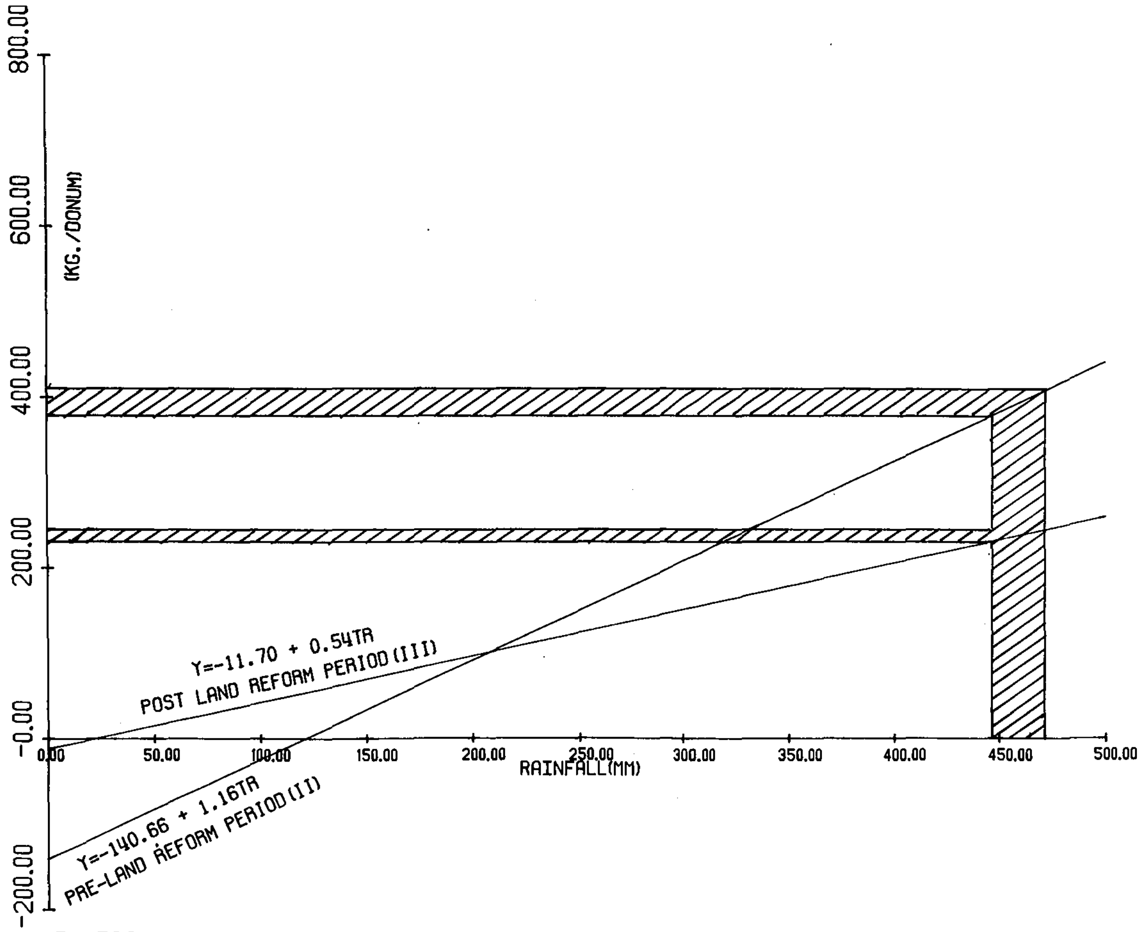
Value in Brackets is the t-value for significance tests

TR = Total Rainfall

FIG. 13.1 THE EFFECT OF RAINFALL ON BARLEY YIELD IN NINEVEH PROVINCE

(Telafar Station)



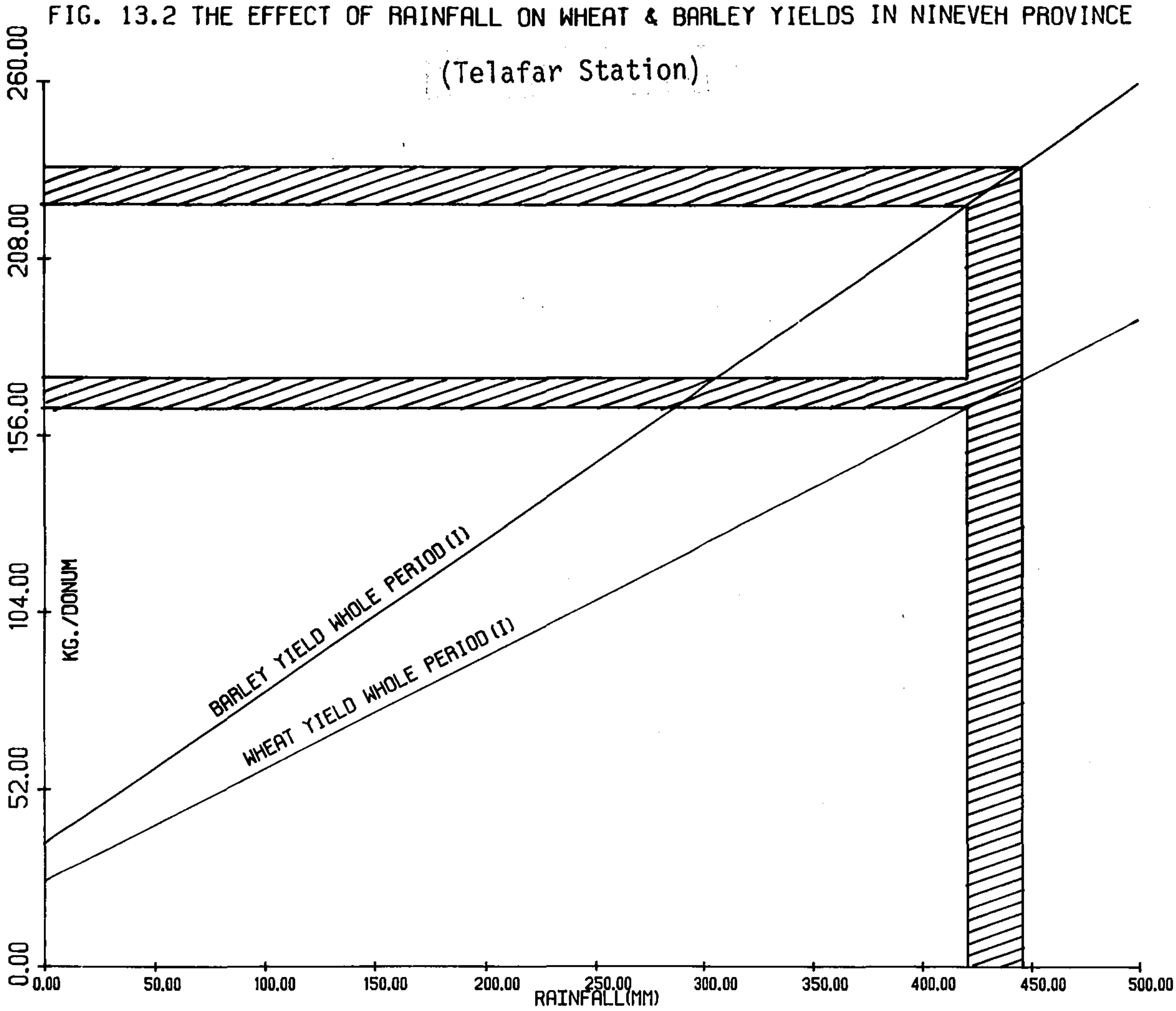


TR=TOTAL RAINFALL

The shaded area shows the increase in yield kg/donum corresponding with increase in total rainfall (mm.).

FIG. 13.2 THE EFFECT OF RAINFALL ON WHEAT & BARLEY YIELDS IN NINEVEH PROVINCE

(Telafar Station)



The shaded area shows the increase in yield kg/donum corresponding with increase in total rainfall (mm.).

of explaining the annual wheat and barley yield variation (R^2) in Nineveh province as well as the significance of the regression function, although the standard errors of barley regression functions are slightly higher. This probably due to high barley yield variation over time (see Table 11.11).

13.7.2 The Effect of Total Rainfall on Barley Yield in Kirkuk Province

In Kirkuk province, mostly a foothill region, all meteorological stations show good results. As in the case of Nineveh province, the total rainfall coefficients in the regression functions are positive except in one function at Iftikhar station where it is negative for the post-land reform period. Nonetheless, this cannot be considered a very accurate function from the statistical point of view because the number of cases is rather small. The full results of these regressions are given in Appendix J, Table J.1.

Hawija Project station has been chosen as the example for the statistical study of the effect of total rainfall on barley yield in this province. Table 13.10 shows the results of the regression functions for four periods. The first function, for the whole period I, explains 35 per cent of the annual barley yield variation in this province. The rainfall coefficient of this function shows an increase of 10 mm. in total rainfall will increase barley yield by 6.82 kg./donum. The second function II (pre-land reform) explains 37 per cent of the annual barley yield variation in this province, and the total rainfall coefficient shows an increase of 10 mm. in total rainfall will increase barley yield by 8.04 kg./donum, which is slightly higher than in the first function. Function III (post-land reform) explains 62 per cent of the annual barley yield variation, which is very high in comparison with other functions in the table. The rainfall coefficient of this function show an increase

Table 13.10 Regression of Barley Yield on Total Rainfall at Hawija Station (Kirkuk Province)

No.	Function	No. of cases	r	r^2	S.E.	F	Notes
I	Y = 13.823 + .682 TR (3.68)	27	.59	.35	77.4	13.56	Whole period
II	Y = 21.585 + .804 TR (2.03)	9	.61	.37	111.1	41.3	Pre-land reform period
III	Y = 40.522 + .823 TR (4.23)	13	.79	.62	49.63	17.88	Post-land reform
IV	Y = 4.066 + .772 TR (3.65)	22	.63	.40	80.83	13.32	22-year

Value in Brackets is the t-value for significance tests

TR = Total Rainfall

of 10 mm. of total rainfall will increase barley yield by 8.23 kg./donum. This means that barley yield becomes more influenced by rainfall. Although this function in particular shows that the effect of rainfall on barley yield has slightly increased during the post-land reform period, results of other stations in this province suggested the opposite (see Appendix J, Table J.1 for details). This latter suggests there were some improvements in the farming system in spite of the decline in barley yield during this period in this province. Fig. 13.3 shows the effect of total rainfall during the pre- and post-land reform period.

Comparing the effect of total rainfall on wheat and barley reveals that barley yield response to total rainfall is greater than wheat yield. Most of the rainfall coefficients in the regression functions are higher in the case of barley than in the case of wheat yield. Here again the question of what grain to grow in a particular season will depend on the rainfall distribution and on the price of these two commodities which, in most cases, favours wheat. Fig. 13.4 shows the response of wheat and barley to total rainfall in Kirkuk province for the whole period.

13.8 The Effect of Monthly Rainfall on Barley Yield

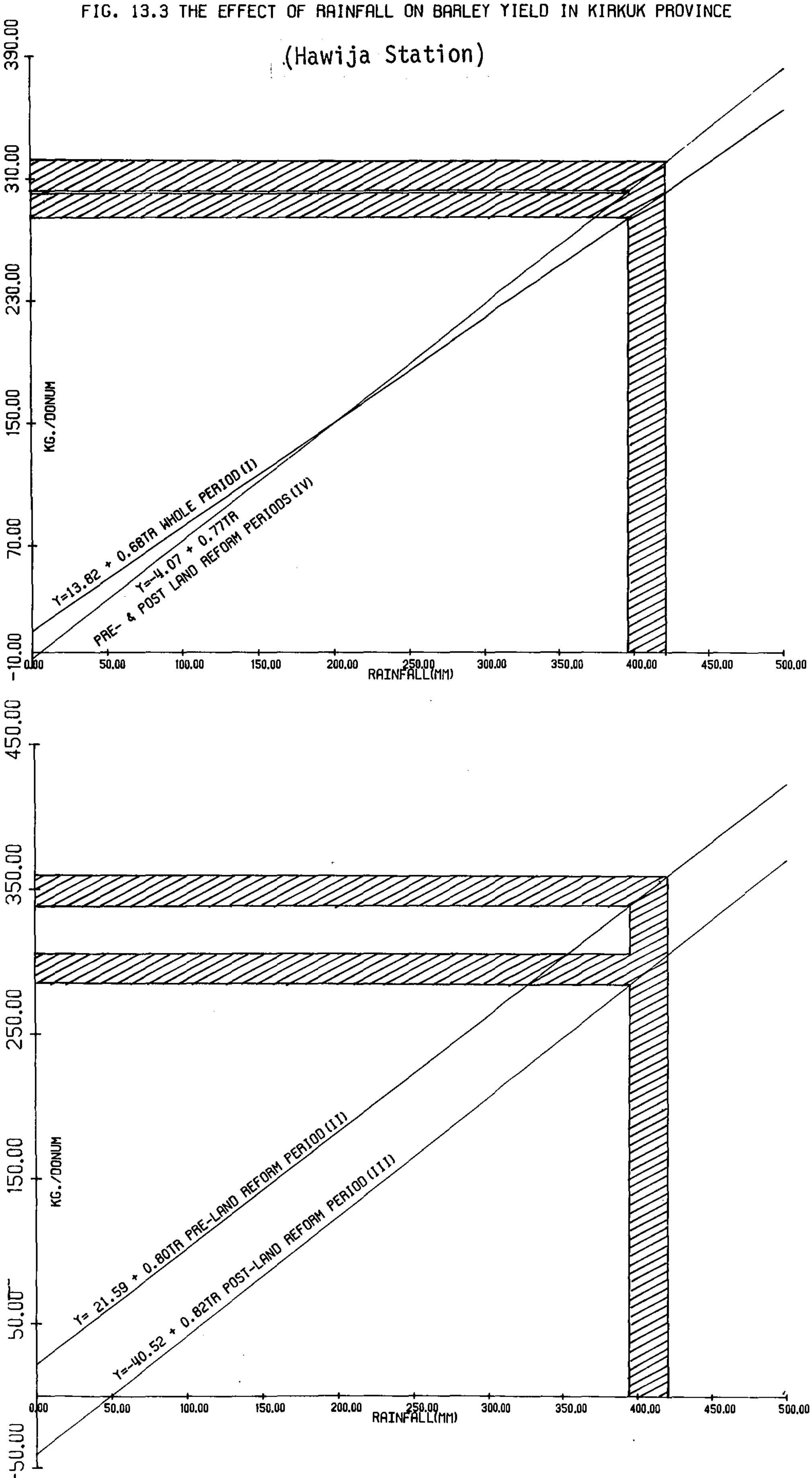
It was noted earlier that early rainfall during October, November, December, January and February are less important to the final barley yield than the late rainfall (spring rainfall) during March and April (see page 536).

In this section, regression techniques will be used to study the influence of monthly rainfall on barley yield in the rainfed area of northern Iraq. The second objective, however, of this regression analysis is to build-up an early forecasting model for barley yield based on rainfall information as in the case of wheat yield.

Appendix J, Table J.2 shows the regression functions of monthly rainfall as independent variables and barley yield as a dependent variable

FIG. 13.3 THE EFFECT OF RAINFALL ON BARLEY YIELD IN KIRKUK PROVINCE

(Hawija Station)

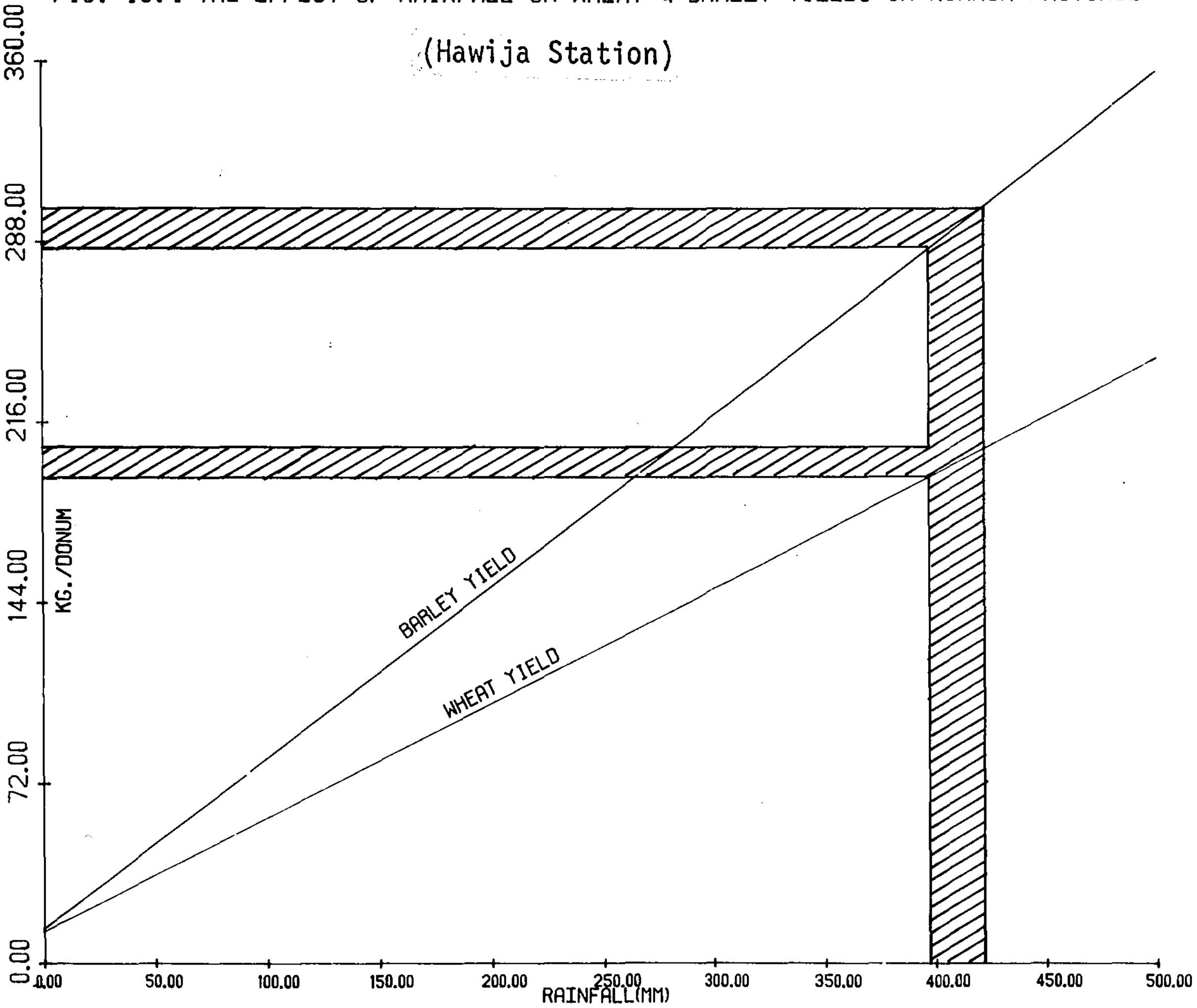


TR=TOTAL RAINFALL

The shaded area shows the increase in yield kg/donum corresponding with increase in total rainfall (mm.).

FIG. 13.4 THE EFFECT OF RAINFALL ON WHEAT & BARLEY YIELDS IN KIRKUK PROVINCE

(Hawija Station)



The shaded area shows the increase in yield kg/donum corresponding with increase in total rainfall (mm.).

at 22 stations in the rainfed area for four periods. For analytical purposes, Table 13.11 summarises the influence of monthly rainfall on barley yield. The following points can be concluded from this table:-

1) October rainfall has a negative influence on barley yield as in the case of wheat, for similar reasons (see page 505). In addition, the number of appearances of October rainfall in the regression function is relatively small.

2) November rainfall tends to be more useful to barley yield, except for Tuz-Khurmatu station during the post-land reform period which shows a negative influence. The importance of November rainfall is associated with plant germination which occurs during this month when sowing is normally early.

3) December rainfall shows a significant effect on barley yield only during the post-land reform period. During this period, December rainfall appears at six stations. This might be explained as follows: first, the statistical distribution of rainfall in months, particularly between November and December, introduces a random factor; secondly, plant germination occurs in early December when sowing is late and thirdly, probably other factors, including micro-climatic, may be influential. As for other periods, December rainfall appears to be less important (see Table 13.11).

4) January and February rainfall is not significantly important in determining the final barley yield. The number of its appearances in the regression functions is very low, or none. The reason for that could be related to first, the already established availability of soil moisture and secondly, the less active growth of the plant itself during this cold period (see Table 13.11).

5) March and April rainfall appears to be the most useful rain for

barley yield. The appearance of these two months in the regression functions occurs more frequently than any other month. This could be related to the active growth period which occurs during these two months.

6) May rainfall tends to have a mixed negative and positive influence on the final barley yield. As for the whole and pre-land reform periods, May rainfall negatively influences barley yield. Meanwhile, the post-land reform and the combination of the pre- and post-land reform periods show May rainfall has a positive influence on the barley yield, and this could be related to the weather conditions during these periods.

It seems rather difficult to draw a firm conclusion on the influence of May rainfall in isolation on barley yield, but it seems that rainfall distribution in April and May taken together is the most effective factor here, especially if one considers the coefficient of rainfall variation of May (see Appendix H, Table H.7 for details).

Therefore, in spite of the fact that early rainfall has shown some significant influence on barley yield, especially November rainfall, late rainfall is still the most effective factor in determining the final barley yield. This, as mentioned before, is related to the farming decisions which farmers have adopted (see pages 538 and 555).

13.9 The Effect of Monthly and Total Rainfall on Barley Yield

The main objectives of this analysis are first, to improve the regression functions which are going to be used for forecasting, and secondly, to find out which is more important in its effects on the final barley yield, monthly rainfall or total rainfall. Appendix J, Table J.3 shows the regression functions at all stations for four periods.

Table 13.11 — The Effect of Monthly Rainfall on Barley Yield in the Rainfed Area

Station	Whole period 27-year, I								Pre-land Reform Period 9 year, II								Post-land Reform Period 13-year, III								Combinations of pre- and post land Ref.Per. 22-years, IV							
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
Sinjar				+			+								+				+	+			+					+			+	
Mosul		+				+								+					+			+	+			+				+	+	
Telafar		+				+								+		-			+		+					+			+	+		
Aqra						+						+							+					+			+					+
Sersank						+														+										+		
Dohuk							+		+					+		-			+			+									+	
Amadiya						+								+	+															+		
Zakho						+						-		+		-						+								+		
Kirkuk		+				+				+				+								+		+						+		
Hawija Project						+								+						+		+		+						+		
Iftikhar							+								+									+							+	
Tuz-Khurmatu				-			+								+			-						+							+	
Skaqlawa					+									+															+			
Arbil	-													+			-								-							
Rawanduz			+																+								+					
Salahuddin																								+								+
Dokan	-																								-							
Sulaimaniya		+		-		+			-	+															-	+						
Halabja										+																					+	
Bakrajo	-	+		-		+		-																		+						
Penjwin		+								-																+						
Chwarta		+				+				+																+						

Considering the first objective there is no significant improvement in the accuracy of the regression functions in relation to that obtained by using monthly rainfall only. In other words, adding a new independent variable, total rainfall, to the regression function is not important. Regarding the second objective, it is clear that rainfall distribution throughout the growing season is very important in determining the final barley yield and this is very logical. This conclusion is made, in the case of Iraq, on the assumption that total rainfall did not appear as an independent variable with other variables in a large number of the regression functions (see Appendix J, Table J.3).

13.10 The Effect of Air Temperature on Barley Yield

Air temperature will be considered in three forms: first, average monthly maximum temperature, secondly, average monthly minimum temperature, and thirdly, average monthly mean temperature. In addition, the average seasonal temperature has been calculated for each of them as an extra variable.

13.10.1 The Effect of Average Monthly Maximum Temperature on Barley Yield

As mentioned before, data on air temperature are available in long series at two stations - Mosul and Kirkuk. Regression techniques have been used to study the effect of average monthly maximum temperature on barley yield at these two stations. The results of these regressions can be seen in Appendix J, Table J.4.

It has already been indicated that average monthly maximum temperature is negatively correlated with barley yield (see Table 13.5). It appears for the whole period (1949/50 - 1975/76) that average November, March and April maximum temperature negatively affect the final barley yield at both stations. In other words, any decline in maximum temperature to a certain level during these months will benefit the yield. High November maximum temperature might adversely affect the final barley yield directly through its influence on plant germination, or indirectly, through its effect on raising evaporation levels, and consequently, lowering of soil moisture levels. March and April maximum temperatures affect grain formation, in addition to other effects mentioned above. These two functions explain 39 and 51 per cent of the annual barley yield variation in Nineveh and Kirkuk provinces respectively, and the standard errors of the regression functions are very close (see Appendix J,Table J.4).

The regression functions at two stations for the pre-land reform period do not match each other. At Mosul station, the regression function shows that average January and May maximum temperatures have a positive influence on barley yield, whilst average seasonal maximum temperature shows a negative influence during Period II. The positive influence of average January maximum temperature might be explained by cold spells which may have occurred during this period (1949/50-1958/59). In this case, any increase in maximum temperature to a certain point will benefit the plant growth, and consequently, the yield. Average January maximum temperature has also a positive influence on wheat yield. This may support the idea of cold spells which occurred during this period. Although high temperature may negatively affect the grain weight during the ripening period (May in the case of Iraq), average May maximum temperature shows a positive influence on barley yield.(1) The only explanation for this is average May maximum temperature during this period might not be high enough to negatively affect the grain weight. In contrast, it may have coincided with the temperature range which helps to dry the grain. The negative effect of average seasonal maximum temperature on barley yield means any decrease in the seasonal maximum temperature to a certain point during the growing season will benefit the final yield. This function, however, explains 97 per cent of the annual barley yield variation during Period II, and the standard error of the regression function is low in relation to other functions (see Appendix J, Table J.4).

The regression function for the pre-land reform period at Kirkuk station shows that average November and April maximum temperatures have a negative effect on barley yield, whilst average December maximum temperature shows a positive effect. This positive effect can be explained in the same way as in the case of January, since December is another cold month. The reasons for the negative effect of average November and April maximum temperature are as explained earlier (see page 510). This function, however, explains 96 per cent of the annual barley yield variation in Kirkuk province during this period.

In contrast to the pre-land reform Period II which shows the importance of maximum temperature in explaining a large proportion of the annual barley yield variation, it seems the average monthly maximum temperature had a limited or no effect on barley yield during the post-land reform Period III. There is no significant explanatory variable in the regression function at Kirkuk station. Meanwhile, the average seasonal maximum is the only explanatory variable in the regression function at Mosul station. The negative effects of average seasonal temperature on barley yield is very clear from this function (see Appendix J, Table J.4).

The regression function for the combination of the pre- and post-land reform Periods, IV at Mosul station shows exactly the same significant months as in the case of the whole period (see Appendix J, Table J.4). This, however, indicates the importance of average maximum temperature on barley yield during these three months, November, March and April. Moreover, this function is more reliable from the statistical point of view than the regression function for the whole period. This improvement in the regression function is probably caused by omitting the five year period which followed the land reform of 1958 from the time series. This indicates that there were abnormal fluctuations in the yield caused by non-climatic factors. In other words, land reform produced non-climatic dislocations of production during this five year period.

Kirkuk station shows only average November and April maximum temperatures have a negative influence on barley yield and also reveals the importance of average maximum temperature during these months in determining the final barley yield. But, the accuracy of this regression function is not as good as the regression function of the whole period (see Appendix J, Table J.4).

13.10.2 The Effect of Average Monthly Minimum Temperature on Barley Yield

Regression analysis has also been used to study the effects of average monthly minimum temperature on barley yield in Nineveh and Kirkuk provinces. The results are given in Appendix J, Table J.4.

At Mosul station, the regression function for the whole period (1949/50 - 1975/76) reveals only average May minimum temperature has a negative effect on barley yield when any decrease in average minimum temperature to a certain point will benefit barley yield. The average May minimum temperature, which is always well above the critical minimum for growth, might help plants through eliminating disease or help seeds to gain more weight (see Tables 11.18 and 11.19). This function, however, explains only 16 per cent of the annual barley yield variation in Nineveh province during this period under study. Moreover, this function is not as accurate as the regression function for average monthly maximum temperature for the same period.

The regression function at Kirkuk station reveals average November minimum temperature has a negative influence on barley yield in the case of the whole period. High November minimum temperature may cause high evaporation, especially if the average November rainfall is taken into account, or it could affect soil temperature, and consequently the spread of fungal disease. Both of these factors also affect seed germination and that will affect the final yield. Moreover, Jen-Hu Chang has cited cases where soil temperature was significant in the early stages of corn germination, but air temperature assumed greater significance in the reproductive stages.[2] It seems any decline in average November minimum temperature will be useful to the plant. This function, however, explains only 12 per cent of the annual barley yield variation in Kirkuk province.

For the pre-land reform period, average November minimum temperature has a negative effect on barley yield at Kirkuk station, whilst at Mosul station October and November minimum temperatures have positive and negative effects on barley yield respectively (see Appendix J, Table J.4). The positive effectiveness of October minimum temperature could be related to weather conditions during this period and, therefore, it will not be considered significant because germination does not start during this month. The negative affect of November minimum temperature has already been explained above.

These regression functions explain 65 and 74 per cent of the annual barley yield variation at Kirkuk and Mosul stations respectively during Period II. As for the post-land reform Period III, there was no significant variable in the regression functions at both stations. This is rather unusual since there were no great differences between the average monthly minimum temperatures during this period from Period II. But, the average barley yield for this period was lower than for the pre-land reform period and that might affect the relation between barley yield and average monthly minimum temperature. Probably other factors also affected barley yield during this period (see Appendix J, Table J.4).

The regression function for the combination of the pre- and post-land reform Periods,IV reveals that average November minimum temperature negatively affects barley yield at Kirkuk station, whilst May minimum temperature negatively affects barley yield at Mosul station. It might be concluded from this discussion that average November and May minimum temperatures have a very strong influence on barley yield at Kirkuk and Mosul stations. The reasons for that might be attributed to the effect of average November minimum temperature on germination and soil moisture, whilst average May minimum temperature may have a direct effect on grain formation or indirectly through affecting soil moisture.

13.10.3 The Effect of Average Monthly Mean Temperature on Barley Yield

The third set of regression functions is between barley yield as the dependent variable and average monthly mean temperature as the independent variable at Mosul and Kirkuk stations. The results of these regression functions are shown in Appendix J, Table J.4.

It appears that for the whole period (1949/50 - 1975/76) that average November and April mean temperatures negatively affect barley yield at Kirkuk station. This also shows the importance of temperature conditions during November and April and their negative effects on barley yield as in the case of maximum temperature (see Appendix J, Table J.4), this for reasons previously given.

At Mosul station, average November mean temperature negatively affects barley yield. This could be attributed to its effect indirectly on evaporation and consequently on soil moisture.

For the pre-land reform period, the regression function at Kirkuk station reveals that average November and April mean temperatures have a negative affect on barley yield. Meanwhile, only the average November mean temperature has a negative affect on barley yield at Mosul station.

As in the case of average monthly minimum and maximum temperature, there are no significant variables in the regression function for the post-land reform Period III at both stations. The only explanation which can be given for that is the decline in the barley yield related to other non-climatic factors.

The regression function for the combination of pre- and post-land reform periods reveals that average November mean temperature negatively affects barley yield at Kirkuk station. Meanwhile, at Mosul station the regression function shows that average January mean temperature positively affects barley yield. This is logical since during January, the coldest month, any increase in temperature conditions could help plant growth. Also in this regression function it is shown that average seasonal mean temperature negatively affects barley yield (see Appendix J, Table J.4).

It can be summarized from this discussion that high temperature conditions during November, April and May have a negative influence on barley yield.

13.11 <u>The Effect of Relative Humidity On Barley Yield</u>

Monthly data on relative humidity are only available at Mosul and Kirkuk stations for long series. Regression analysis has been used to study the effect of relative humidity on barley yield. The results of these regression functions can be seen in Appendix J, Table J.5.

At Kirkuk station, the regression function reveals that average December and April relative humidity levels positively affect barley yield during the whole Period I. Since relative humidity affects photosynthesis rate and moisture absorption from the air by the plant, it is not surprising to see the positive effects of December and April relative humidity on barley yield.(3) These two months (December and April) coincide with the germination and very active growth periods respectively. Only average April relative humidity appears to have a positive effect on barley yield during the whole period at Mosul station. This also tends to confirm the importance of April relative humidity. These two functions explain 51 and 45 per cent of the annual barley yield variation during this period in Kirkuk and Nineveh provinces respectively.

For the pre-land reform period, the regression function shows that average March and April relative humidity have a negative and positive effect respectively on barley yield at Kirkuk station. It is rather surprising to see that average March relative humidity has a negative effect on barley yield. According to Jen-Hu Chang, relative humidity has at least two possible beneficial effects on plant growth, especially during the active growth period of March in the case of Iraq.(4) At Mosul station, average January and March relative humidity have positive effects on barley yield during this period. Nonetheless, both functions explain 83 and 84 per cent of the annual barley yield variation in Kirkuk and Nineveh provinces respectively during this period.

The regression function at Kirkuk stations shows that average October relative humidity negatively affects barley yield during the post-land reform period. Here, it seems that average October relative humidity has the same pattern as October rainfall in terms of its effects on barley yield. Average March and May relative humidity have beneficial effects on barley yield in the same function (see Appendix J, Table J.5). Meanwhile, only average May relative humidity positively influences barley yield at Mosul station for the same period.

Regression function for the combination of pre-land and post-land reform Periods, IV reveals that average January and April relative humidity have beneficial effects on barley yield at Kirkuk station, but only average April relative humidity positively affects barley yield at Mosul station.

It seems relative humidity at the early stages shows little effects on barley yield in spite of the appearance of October, December and January in the regression functions, except for January in the one case which is very significant. But, relative humidity becomes more important in the late stage of the growing season. The reason for that could be related to: first, more water is demanded by plants during the late period and that might increase the importance of relative humidity, especially if photosynthesis is taken into consideration, and secondly, a large proportion of barley production is spring-sown and that is why relative humidity during December and January appears in many regression functions.

13.12 Forecasting Barley Yield From Meteorological Observation

In the previous chapter yield forecasts have been defined as an early estimate of the yield before the actual harvest takes place. An attempt to make a unique forecasting formula for barley yield for the whole rainfed area was not very successful. This is due to the fact that the relation between barley yield and rainfall in the upland region of Sulaimaniya and Arbil provinces was not very significant. Therefore, as mentioned before, aggregating meteorological and agricultural data may affect the accuracy of the forecasting formula. Here, forecasting barley yield will be restricted to Nineveh and Kirkuk provinces. Moreover, these two provinces produce nearly 80 per cent of the total barley production of the rainfed area.

In this chapter several regression functions have been developed to assess the effect of each individual weather factor on barley yield. Any of these functions may be used for forecasting barley yield according to the purposes of the forecast. In addition to the previous regression functions, one more regression function has been developed for each period. As in the case of wheat, the new forecasting functions are based on a combination of all weather variables available at two meteorological stations in each province (see pp. 517-18). The selection of the weather variable in the regression function is made by using a stepwise regression analysis (see page 494). Tables 13.12 and 13.13 show the regression functions for each period for forecasting barley yield in Nineveh and Kirkuk provinces respectively. It is clear from these tables that these regression functions provide more accurate results than the previous functions (see Appendix J for details), and consequently, they could be used for barley yield forecasts. Appendix J, Tables J.6 shows the actual and forecasted barley yields in Nineveh and Kirkuk provinces.

The range of accuracy of the forecasting functions is between $\pm$ 3.20 to $\pm$ 27.14 per cent of the average actual barley yield in Nineveh province and ranging between $\pm$ 7.41 to $\pm$ 33.72 per cent of the average barley yield in Kirkuk province. Table 13.15 shows the relative accuracy (positive and negative) of forecasted barley yield against actual yield for the whole period 1950-1976 utilizing the 22 year period formula shown in Tables 13.12 and 13.13. It is clear from this table that no trends are observable in accuracy in either province or in any period or sub-period; this appears to confirm the absence of any overall trend in barley productivity due to improved farming system in the rainfed area of Northern Iraq. Also, it is clear from Table 13.15 that there was a period of dislocation between 1958 and 1963 following the land reform. The last point which appears from Table 13.15 is that all but one forecasting function for barley yield in Nineveh province shows greater accuracy than those for Kirkuk province (see also Table 12.12 and 12.13). Table 13.15 shows that for the 13 post-land reform years only 9 of the 13 years shows discrepancies of less than 10 per cent, whilst in Kirkuk only two are less than 10 per cent (see p.518). Fig. 13.5B shows the percentage differences between actual and barley yields in both Nineveh and Kirkuk provinces. Meanwhile, Fig.13.5 shows the actual and forecasted barley yields in both Nineveh and Kirkuk provinces. It seems that the lower accuracy of barley forecasts in Kirkuk province is associated with a negative trend in barley yield (see Table 11.9).

The considerable variations in accuracy in barley yield forecasts both after time and between provinces raises considerable reservations about the usefulness of such forecasts at the moment. We know that barley is often regarded as a crop of secondary importance in that it is generally grown in areas more physically marginal than are used for wheat. One aspect of this was noted on page 555 as it affects the timing of sowing. Clearly there is statistical evidence for there being less domination of barley yields by the selected climate factors than was the case with wheat. The 1973-1975 percentage accuracy figures for Nineveh province are so different in order from all other cases between 1964 and 1976 that one is also led to suspect the accuracy of the reported production data. 1973 was also the first year in which there was a government drive to introduce barley HYVs but no details are available about this programme. Clearly further research and improvement of data collection are necessary before any very accurate forecasting of barley yields can be made.

13.13 Conclusion and Final Remarks

Apparently, the effect of total rainfall on barley yield is least significant in the upland region of Arbil, Sulaimaniya and the northern part of Nineveh province, where the annual rainfall is higher than anywhere else. The reasons for this have already been given (see page 468). The effect of total rainfall on barley yield on the foothill region, however, is more significant: any increase in the total rainfall will increase barley yield.

Table 13.12 Forecasting Equation for Barley Yield in Nineveh Province

No.	Function	No. of cases	R	R^2	S.E.	F
I	Y_B = 291.68 - 13.77 MAT2 - 14.58 MAT3 + 6.57 RH7 (2.25) (2.45) (5.99)	27	.83	.69	50.77	17.39
II	Y_B = 1488.0 - 1.58 R3 - .29 R5 - 87.68 MT2 (15.65) (3.86) (28.28) - 4.73 RH1 + 4.32 RH7 (4.98) (13.28)	9	.99	.99	5.98	558.83
III	Y_B = 268.23 + .544 TR - 12.64 MT1 (7.36) (2.02)	13	.92	.85	33.52	28.97
IV	Y_B = 172.91 - 24.08 MAT3 + 11.16 MIT4 - 5.54 RH5 (4.57) (2.1) (2.58) + 5.85 RH6 + 5.61 RH7 (3.32) (4.48)	22	.92	.85	40.84	18.14

MAT2 = Average November Maximum Temperature
MAT3 = " December " "
RH7 = April Relative Humidity
R3 = December Rainfall
R5 = February "
MT2 = Average November Mean Temperature
RH1 = October Relative Humidity

TR = Total Rainfall
MT1 = Average October Mean Temperature
MIT4 = Average January Minimum Temperature
RH5 = February Relative Humidity
RH6 = March Relative Humidity
Value in Brackets is the t-value for significance tests

Table 13.13   Forecasting Equations for Barley Yield in Kirkuk Province

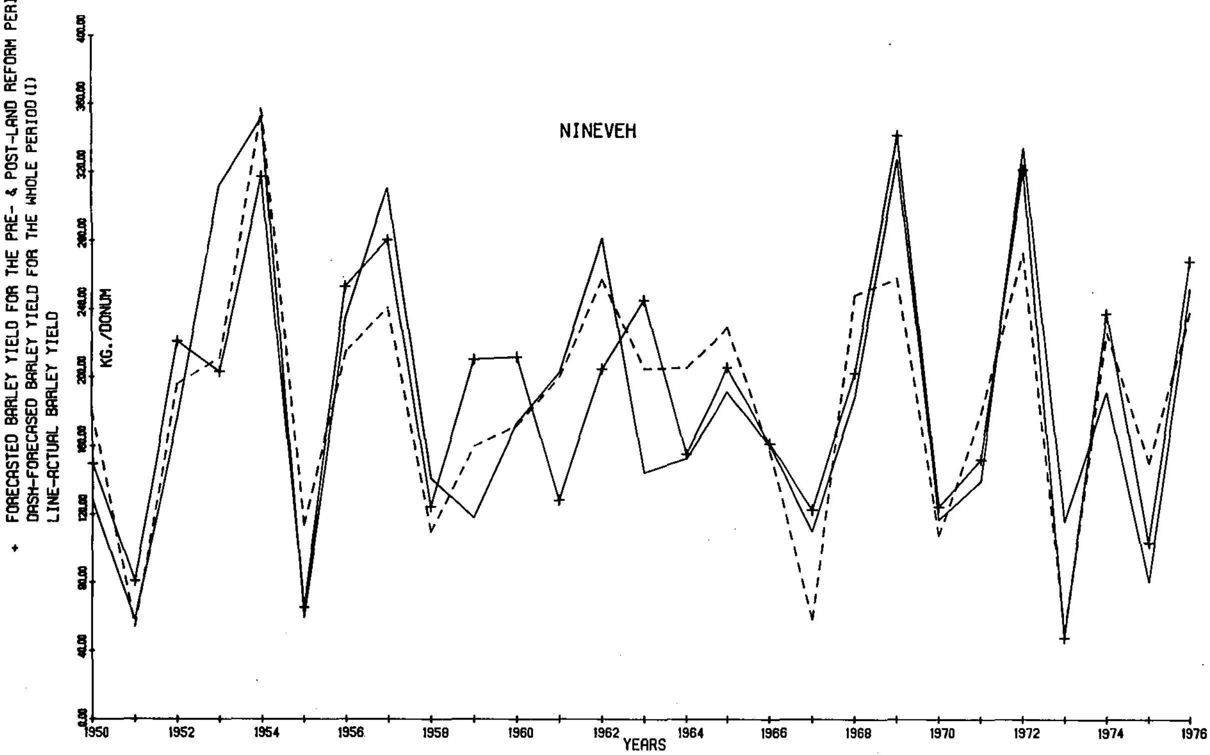
No.	Function	No.of cases	R	R^2	S.E.	F
I	Y = 187.60 - 20.93 MAT2 + 3.16 RH6 + 5.71 RH7 (3.66) (1.96) (3.84)	27	.83	.69	56.22	16.70
II	Y = 1078.7 - 88.81 MAT7 + 54.15 MIT8 + 6.21 RH4 (23.15) (13.28) (5.69)	9	.99	.99	13.94	234.00
III	Y = -128.23 + .84 R3 + 4.11 R8 + .48 TR (3.08) (7.59) (7.73) + 24.72 MIT4 - 14.18 MIT7 + 3.40 RH6 (8.77) (5.37) (7.10)	13	.99	.99	12.11	79.85
IV	Y = 294.89 - 20.48 MAT2 + 7.16 RH7 (2.71) (4.55)	22	.81	.65	63.44	17.55

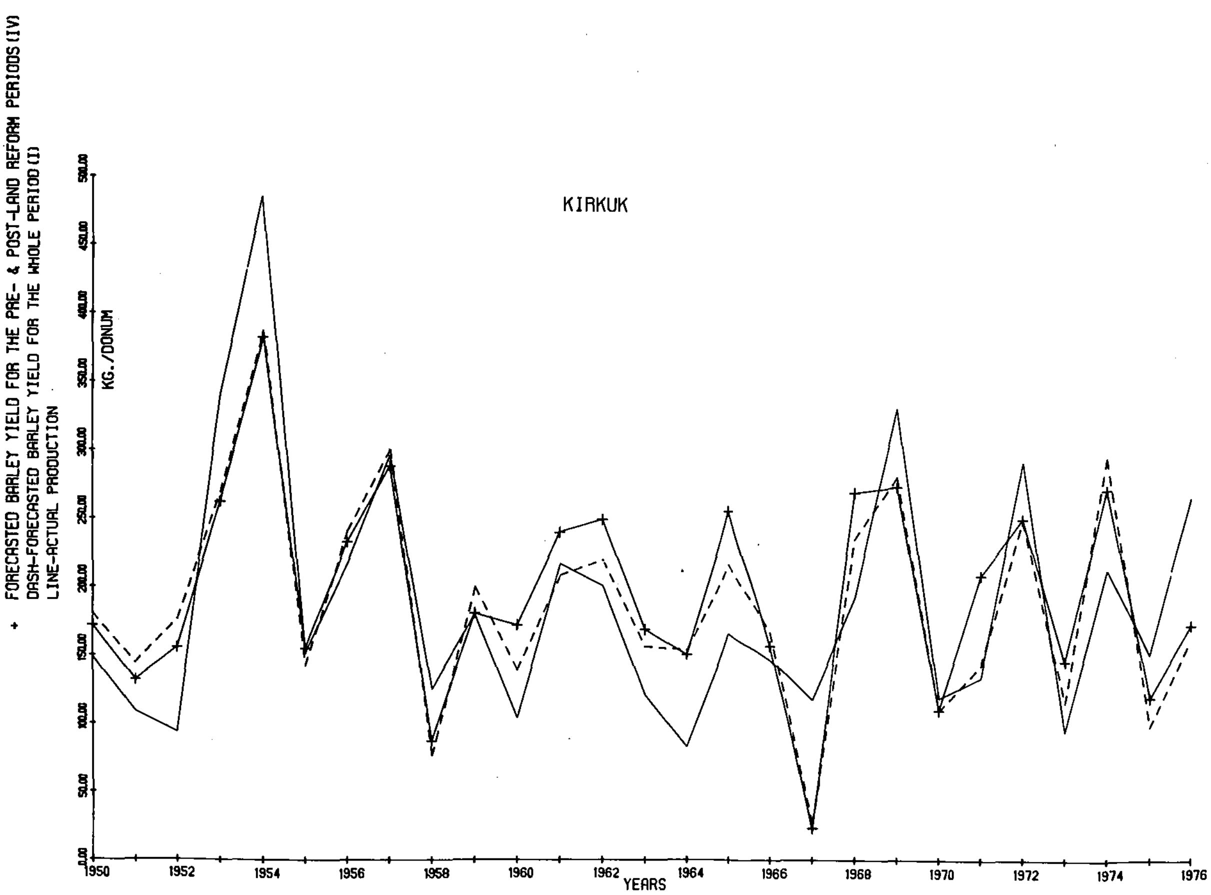
MAT2 = Average November Maximum Temperature
RH6 = March Relative Humidity
RH7 = April " "
MAT7 = Average April Maximum Temperature
MIT8 = " May Minimum "
RH4 = January Relative Humidity
R3 = December Rainfall
R8 = May Rainfall
TR = Total Rainfall

MIT4 = Average January Minimum Temperature
MIT7 = " April " "

Value in Brackets is the t-value for significance tests

FIG. 13.5 ACTUAL & FORECASTED BARLEY YIELDS IN NINEVEH & KIRKUK PROVINCES





The response of barley yield to total rainfall appears greater than that of wheat. This is associated with the fact that farmers in the rainfed area choose to cultivate barley rather than wheat in years when rainfall in the early season is not adequate for wheat sowing, and they cultivate barley in more arid regions.

It seems, as in the case of wheat, that the pre-land reform period was dominated by environmental conditions, especially rainfall, whilst the effect of rainfall on barley yield decreased during the post-land reform period. This means there was a slight improvement in farming practice during this period in spite of relative decline in barley yield. The 22-year Period IV shows more improved results compared with the whole Period I, indicating that there was a dislocation period which followed the land reform of 1958, i.e. there were other factors affecting barley yield.

The relation between monthly rainfall and barley yield reveals that early rainfall is less important to barley yield in comparison to wheat yield. The main reason for that is related to the farming practice. Barley is usually a spring or late autumn-sown crop. If early rainfall is not adequate for wheat production, farmers may cultivate spring barley in order to obtain reasonable incomes. Meanwhile, March and April rainfall show a very significant and positive affect on barley yield. This is due to the active growth period which coincides with these two months.

Temperature, in general, affects barley yield negatively, especially during November, March and April. During November temperature could affect barley yield through evaporation, and consequently, through the availability of soil moisture, especially if the average November rainfall is considered. During March and April, temperature could affect barley yield directly through plant response or indirectly through the availability of water.

Table 13.14 The Regression of HYV's of Barley on Total Rainfall in Three Experimental Farms in The Rainfed Area of Iraq

	No.of cases	r	r^2	S.E.	F
Mosul Experimental Farm					
Y_I = 403.89 + 1.0584 TR (1.06)	5	.56	.31	193.23	1.38
Y_B = 272.28 + 1.0155 TR (1.09)	6	.48	.23	205.14	1.20
Telafar Experimental Farm					
Y_I = -480.91 + 2.3280 TR (1.86)	4	.80	.63	273.67	3.44
Y_B = -98.272 + 1.774 TR (1.06)	4	.60	.36	242.36	1.12
Bakrajo Experimental Farm					
Y_I = 1788.1 - 1.4210 TR (7.00)	4	.98	.96	51.38	49.02
Y_B = 1715.6 - 1.6543 TR (2.46)	4	.87	.75	170.5	6.03

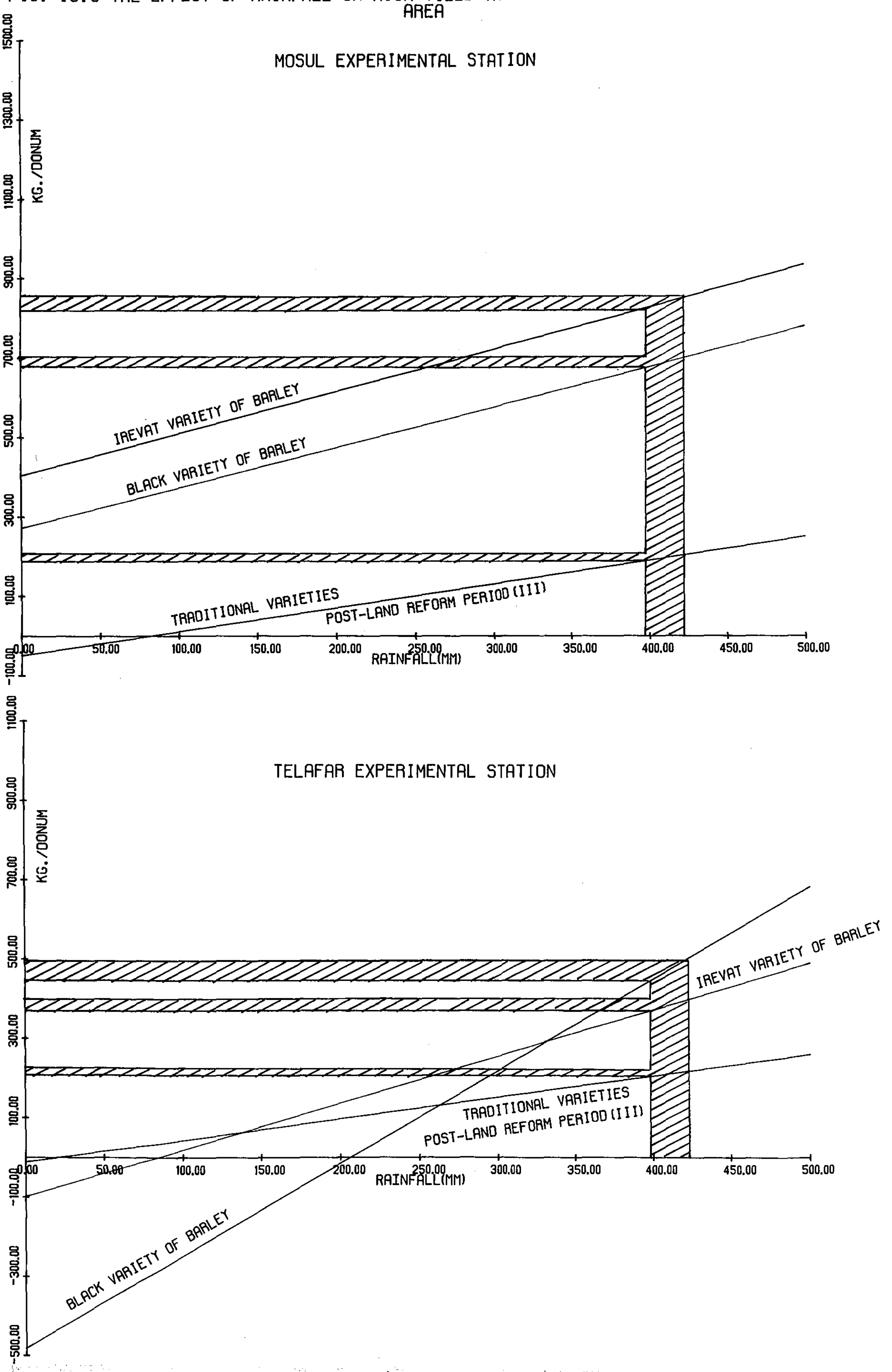
Value in Brackets in the t-value for significance tests

Y_I = Yield of Irevat variety of Barley

Y_B = " Black " " "

TR = Total Rainfall

FIG. 13.6 THE EFFECT OF RAINFALL ON HIGH YIELD VARIETIES OF BARLEY IN THE RAINFED AREA



The shaded area shows the increase in yield (kg/donum) corresponding with increase in total rainfall (mm.).

Relative humidity significantly and positively affects barley yield, especially during March and April. The reason for this could be related to greater water requirement by the plant during the active growth period during these two months when plants can absorb water both through leaves and roots.

In the case of wheat, it was assumed that HYV's of wheat could be introduced to improve wheat yield to the rainfed area in association with certain other input requirements and an integrated policy programme. Here, the possibility of adopting HYV's of barley is examined. Data on HYV's of barley have been obtained from three experimental farms in the rainfed area. The same assumptions made in the case of wheat are adopted here (see page 525).

Table 13.14 shows the regression function of two HYV's of barley and total rainfall for three experimental farms. It is clear from this table that total rainfall has a negative effect on HYV's of barley yield in Bakrajo Experimental Farm. This means that there were other factors affecting barley yield in this station. Comparing, however, the response of traditional varieties with HYV's of barley, Fig. 13.6 shows that the response of HYV's of barley to total rainfall is greater than with the traditional varieties. Here, one may assume that there is a good possibility of improving barley yield in the rainfed area by introducing HYV's but only if all other necessary factors, i.e. fertilizers, extension, etc., are improved.

Forecasting barley yield from meteorological data was only attempted for Nineveh and Kirkuk provinces of the rainfed area. No attempt was made to make a forecast for Arbil and Sulaimaniya provinces because first, the lack of other meteorological data, i.e. temperature and relative humidity, and secondly, the low relationship between rainfall and barley yield in these two provinces. The value of these forecasting formulae depends on the forecast purpose and the objective of the user.

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(3) Ibid, p.231.

(4) Loc.cit.

SECTION FIVE

CHAPTER FOURTEEN

CONCLUSION

Iraq is one of the developing countries which has given considerable attention to agricultural development in recent years. The shortages and fluctuations in international food supply, the continuous increase in population, in many cases the relative increase in per-capita food consumption, and other factors, were the justification for agricultural development programmes. However, these agricultural development programmes have not been as successful as those in other economic sectors. Agricultural production, especially food production, has not kept pace with increasing demand, and gradually many developing countries, including Iraq, have become more dependent on importing food from the large producing countries. This deficit in food production is not only affecting national balances of payment, but also can have more serious consequences, such as deteriorating nutritional situations, worry over food security, etc., and this in countries with numerically large agricultural populations as well as rapidly growing urban centres.

The main objective of this study was to consider the various factors affecting agricultural production and productivity in Iraq with especial emphasis on the role of weather and climate. These factors have been grouped into three major type categories: socio-economic, technical and environmental (see Fig. 1.1). Clearly, there are strong interrelations and interactions between these factors, and, therefore, studying the effect of a single group of factors, such as weather and climate, cannot be carried out in isolation from the others and thus one has examined, in turn, the effect on production and productivity of these groups of factors.

The final objective of studying the impact of weather and climate has been achieved by concentrating on the rainfed area of northern Iraq. The reasons for selecting the rainfed area of northern Iraq as a study area can be summarized as: first, it is a dry farming area in which human modification of environment is minimal; secondly, it is relatively free from the soil salinity which introduces variable complexities in the Central and Southern regions and thirdly, it is dominated by the winter cultivation of two staple grains, wheat and barley, which provide suitable indicators for statistical analysis and international comparison.

Wheat and barley, therefore, have been chosen to study the impact of certain weather factors on agriculture. These two crops are especially important in Iraq because of government attempts to be self-sufficient in these grains, and secondly, because they are the most important crops in terms of area and value in Iraq in general, and in the rainfed area in particular (see Chapter 11).

Under those conditions where environment is least modified by men, i.e. rainfed agriculture, we see that the control of climate is significant on agriculture. Similarly, where environment is partly or fully modified, i.e. in irrigated agriculture, we see that the control of climate on agriculture is less directly important, although indirectly critical.

How do we now set this in the context of the socio-economic and technical factors which we have examined earlier? The effect of these factors on agriculture can be measured in three ways : first, their direct effect on rainfed agriculture, secondly, on irrigated agriculture and thirdly, on the potential development of agriculture in these two different types of farming which are also regionally distinct.

Agriculture in Iraq, as in many developing countries, is very important - it provides employment for a large proportion of the working population (see Chapter 2) and its contribution to the gross national income is significant, regardless of annual fluctuations and excluding oil revenue (see Chapter 3). Under Iraqi conditions, where agricultural conditions are harsh, every single input factor has a critical value in the complex network of forces. Also, the development of agriculture demands various skills at different levels without which improvements in production and productivity are difficult to achieve, and finally all the inputs and skills have to be evaluated in a context of strong environmental controls of agriculture.

Iraq, unlike many developing countries, possesses good potential for agricultural development. Currently, only 27 per cent of the cultivable land is cultivated annually (excluding the fallow land), this in a country where arable farming is the most important (see Chapter 4). Water resources are potentially more than enough for current cultivation and probably enough for further expansion of the cultivated land, but only if good water management and utilization are improved (see Chapter 9). Population pressure, especially that of the rural population on cultivable land,is not as high as in many developing countries because of rapid rural-urban migration after the oil price increases in 1973 (see Chapter 4).

Following the establishment of the Development Board in 1950, the Iraqi government gave first priority to agricultural development, especially before the 1958 revolution. Agriculture received the largest share of planned government investment during this period. Most of this investment, however, went to large engineering projects to control water resources in both the Euphrates and Tigris rivers, and to a lesser extent either to expand the cultivated area or improve farming standards. Investment to improve agricultural productivity was not significant during the pre-land reform period (see Chapter 3). Therefore, the absence of such investment in socio-economic aspects as a whole led to rather slow or poor returns from such large engineering projects. Private investment in agriculture was not significant during this period. Large landlords were not primarily interested in improving land productivity (see Chapter 3) and, on the other hand, insecure land tenure and poor landlord-tenant relationships discouraged tenant farmers from investing in agriculture (see Chapter 5).

After the 1958 revolution, agriculture faced many changes. Among these changes was the introduction of the Land Reform Law of 1958 and consequent legislation. In many ways, the institutional and administrative changes which followed land reform removed, without any doubt, some of the obstacles which had prevented previous significant improvement in agricultural development. Abolishing the semi-feudalistic pattern of land tenure, improving landlord-tenant relationships, distributing land to the peasant farmers and encouraging cooperatives were hypothetically useful measures to improve agricultural production and productivity. The land reform itself, however, was not free from problems in Iraq; poor implementation and bad management resulted in very limited success, especially in improving agricultural productivity. Land expropriation and distribution took longer than was originally planned (see Chapter 5). Agricultural production fell significantly immediately after the Land Reform Law of 1958 (see Chapter 5). Here, one may conclude that land reform in Iraq achieved its political and probably social targets more successfully than the economic one. So also in Iraq, the programme suffered in the first five years (1958-1963) owing to the inability to sustain administratively the complex of supporting services necessary for the successful outcome of land redistribution schemes.(1)

Another major change associated with the 1958 land reform was the establishment and encouragement of agricultural cooperatives as a major form of agricultural administration and organization. They were not a complete success in spite of direct government intervention by providing subsidized credits, supervision, etc. (see Chapter 6). Though the number of agricultural cooperatives, their members and the area under their control have significantly increased, the basic idea that agricultural cooperation would achieve a good response from farmers, and consequently promote agricultural production, was hypothetical rather than actual (see Chapter 6). Many farmers considered cooperatives as official government departments rather than organisations in which they themselves would participate and cooperate, this on the one hand related to a lack of understanding and high illiteracy and, on the other, to poor extension services on the technical side.

Analysing the investment pattern which followed the 1958 revolution reveals that total planned government investment continuously increased during this period, but the share of agricultural investment declined (see Chapter 3). However, the actual government expenditure in agriculture was the lowest among all economic sectors. This was probably a major set-back for agriculture when, in reality, extra investment was highly important to cover at least the cost of institutional and administrative changes, particularly in a period when the role of the state, compared with the private sector, was being enlarged. The only significant change was that investment in agricultural services was gradually improved. Nonetheless, these increases were not enough to increase agricultural productivity significantly, especially if one considers the size of investment required in agricultural services during this period when agriculture was facing major institutional and administrative changes.

As noted earlier, the institutional changes increased the government's control of input factors as well as production and the distribution of most input factors became the function of the government. Basically the main reason for that was the assumption that government should fill the gap which was left by the dispossessed landlords in providing agricultural services to the new land reform beneficiaries. The available evidence, however, suggests that input factors, such as HYV's and fertilizers were not extensively taken up by farmers throughout the country, especially in grain production (see Chapter 7). It has been argued that the use of new technology ultimately depends on other socio-economic factors, such as farmers' willingness to change, certain economic incentive schemes and on environmental factors as well.

This has been the case in Iraq. Although the government subsidized most of the new input factors, farmers' response in the use of such input factors was low, especially in grain production (see Chapter 7). This may reflect four points : first, farmers in Iraq traditionally and still adopt a policy which is based on low investment and low risk. This point becomes very clear if one considers the utilization of HYV's and fertilizers in the rainfed area of northern Iraq (see Chapter 7); secondly, the ineffectiveness of economic incentive schemes, such as pricing policy and marketing organization (see Chapter 3); thirdly, the absence of active extension services (see Chapter 6), and fourthly, environmental conditions remained more important than was administratively recognised. Clearly, the interrelation among these points is very important.

It seems in particular that the effectiveness of extension services is the key factor in such a situation to obtain a response in agricultural development, and farmers willingness of change will especially depend on such effectiveness. For example, farmers still practice a simple annual fallow farming system. Accordingly, half of the cultivated land is cropped annually leaving the other half to rest for the next season. Farmers using this crop-fallow farming system in the rainfed region believe that this system improves soil moisture (see Chapter 9). In the irrigated area, however, the fallow system is practiced to reduce the water table and to decrease or control soil salinization (see Chapter 9). Summer cultivation in both cases is restricted to relatively small areas.

Improving the farming system, and consequently obtaining high yield, requires highly skilled farmers and this cannot be achieved, especially in Iraqi conditions, without active extension services. Improving the farming system in the irrigated area is not only a matter of supplying irrigation water, but also requres a full knowledge of other factors, such as timing of irrigation, irrigation duties for each crop, providing and maintaining good drainage systems, adoption of rotation systems to maximize the use of water and improve soil conditions. In the rainfed area, to change from the dry-fallow system to a true dry farming system also requires different but good skills and good management, i.e. timing the farm operations to ensure they coincide with rainfall occurrence, selecting the right crops for rotation purposes, using the appropriate equipment, ploughing, etc.

Clearly, improving the farming system will depend considerably on the effectiveness of extension services, especially in Iraq where farmers' education is low and environmental conditions are critical, partly on the availability of the right equipment and by creating an economic environment that is seen by farmers to justify such changes.

Apparently, the government has been unable to provide adequate services which agriculture badly required despite the increase of expenditure on agricultural services and direct government intervention in agriculture through the state and collective farms, farm machinery rental stations, providing extension and other services. The state farms were neither comprehensively successful as extension nor as commercial farms (see Chapter 6). Farm machinery rental stations were not efficient and worked at substantial losses (see Chapter 8). Although, the private sector owned the largest share of farm machinery in Iraq, it's ability to provide adequate services at the right time and at the right place is still a matter of concern (see Chapter 8). The availability of farm machinery at the right time and at the right place is vital to improve the farming system in both the irrigated and rainfed areas.

Given all these shortcomings with socio-economic and technical factors,we see that agriculture is still largely controlled by environmental conditions. In the rainfed area it has been established that a large proportion of the annual yield of wheat and barley variation is related to the seasonal rainfall (see Chapters 12 and 13). The statistical analysis indicates that there has been some relative improvement in farming practice, but such improvement was not enough to show any trend of increase in productivity.

Agricultural production before 1958 was dominated by environmental conditions, especially by rainfall in the rainfed area (see Chapters 12 and 13). Studying the impact of rainfall on the yield of wheat and barley reinforces other evidence that there was a period of dislocation which followed the introduction of land reform. Meanwhile, in the irrigated area, the inefficient use of water resources combined with harsh environmental conditions, such as high temperature and high evaporation, haveresulted in low efficiency of water use and the continued build-up of salts on the top soil which decreased land productivity (see Chapter 9).

Clearly, the impact of environmental conditions in general and weather conditions in particular on both irrigated and rainfed agriculture is negatively affected by the level of development of the socio-economic and technical sectors. In that sense, one may formulate some recommendations for the future development of agriculture in Iraq:-

1. Agriculture planning should be more comprehensive and integrated. Basically, two farming systems should be recognized in such plans, irrigated and rainfed agriculture, each of them requiring integrated social, economic and technical programmes appropriate for their fundamental characteristics.

2. Agricultural investment should be substantially increased, especially on agricultural services, to make for more balanced economic growth and to give agriculture a real push.

3. Agricultural planning should consider improving agricultural productivity as its first priority (vertical development). This approach would have many socio-economic and technical advantages, especially in the long term.

4. Improving marketing institutions, marketing intelligence and pricing policy are necessary to give farmers the real incentive to improve agricultural productivity.

5. Introducing crop insurance schemes could minimize the risks involved in agricultural production. Such schemes may therefore encourage farmers to invest in agriculture, especially when they know that their crops are insured against natural disasters.

6. Improving agroclimatic studies in both irrigated and rainfed areas, is extremely important. Such studies would provide vital information which can be fed back to the planning system at different levels but especially at

the farm level.

An acceptance of these basic principles in future agricultural development would help to improve agricultural production and productivity, and consequently would have many significant impacts such as decreasing food imports, safeguarding water-supplies, controlling rural-urban migration and improving the rural development as a whole. In reality, the adoption and execution of such planning is totally dependent on government policy since the state has assumed responsibility for all the key elements in agriculture. Such policy, then, has to recognise the complex interdependence of forces which govern production and productivity in agriculture.

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APPENDICES

Appendix A

Table A.1 Annual Planned Government Investment Between 1951-79

I.D. Thousands

Sector / Year	Agriculture			Industry	Transport and communication	Building and Services	Total
	Reservoirs, Irrigation, Drainage	Agricultural Services	Total				
1951	3,024	450	3,474	50	2,642	3,028	9,194
52	7,100	1,300	8,400	3,000	4,800	3,800	20,000
53	10,840	2,150	12,990	5,000	5,350	4,450	27,790
54	11,950	2,400	14,350	6,000	5,950	4,650	30,950
55	14,105	860	14,965	4,119	16,068	8,506	43,658
56	25,500	2,700	28,200	17,000	20.250	15,700	81,150
57	27,900	2,700	30,600	16,000	29,300	24,800	100,700
58	28,000	2,300	30,300	11,000	34,150	23,200	98,650
59**	30,250	2,300	32,550	9,000	22,100	22,350	86,000
59*	12,295	2,190	14,485	9,761	22,457	30,523	77,226
60	14,288	3,853	18,141	12,568	36,190	70,044	136,943
61**	8,717	4,176	12,893	10,450	26,205	51,520	101,068
61*	13,405	6,147	19,552	14,424	24,860	38,073	96,909
62	13,510	6,669	20,179	24,675	32,410	30,792	108,056
63	16,990	5,770	22,760	39,607	29,800	25,457	117,624
64	19,470	5,228	24,698	43,008	27,890	24,009	119,605
65	11,485	14,353	25,838	32,100	26,566	29,610	114,114
66	15,773	13,728	29,501	42,573	23,570	23,813	119,457
67	17,193	12,603	29,796	39,816	20,997	22,668	113,277
68	20,340	19,599	39,939	39,540	20,702	23,520	123,701
69	11,520	10,887	22,407	21,000	12,000	15,000	70,407
70	14,900	13,100	28,000	28,000	15,268	13,000	84,268
71	30,700	29,300	60,000	50,000	28,000	28,000	166,000
72	13,082	10,129	23,211	28,000	16,000	22,000	89,211
73	35,200	29,800	65,000	60,000	40,000	45,000	210,000
74	56,200	133,800	190,000	225,000	120,000	175,000	710,000
75**	54,300	153,200	207,500	448,000	166,000	188,000	1,009,500
76			268,000	709,000	242,500	213,200	1,432,700
77			389,877	966,000	351,600	368,045	2,075,522
78							2,800,000
79							3,283,000

* Three months

** Nine months

Source:
1. Shammem, A.A. and Al-Waeth, A. (1972) : Follow-up Report on The Economic Plans Fulfilment in Iraq between 1951 - 74, Ministry of Planning, Baghdad, Iraq (in Arabic).
2. Saman, B.B. (1975) : The Reality of Agricultural Planning in Iraq, Ministry of Planning, Baghdad, Iraq (in Arabic).
3. Ministry of Planning : Statistical Abstract of 1976, Baghdad, Iraq.

Table A.2 **Distribution of Planned Government Investment According to Economic Sectors**

Sector / Year	Agriculture: Reservoirs, irrigation, drainage	Agriculture: Agricul-tural services	Agriculture: Total	Industry	Transport and communic-ation	Building and services	Total
1951	87.0	12.0	37.8	0.5	28.7	32.9	100
52	84.5	15.5	42.0	15.0	24.0	19.0	100
53	83.4	16.6	46.7	18.0	19.3	16.0	100
54	83.3	16.7	46.4	19.4	19.2	15.0	100
55	94.2	5.8	34.3	9.4	36.8	19.5	100
56	90.4	9.6	34.7	21.0	25.0	19.3	100
57	91.2	8.8	30.4	15.9	29.1	24.6	100
58	92.4	7.6	30.7	11.2	34.6	23.5	100
59**	93.0	7.0	37.8	10.5	25.7	26.0	100
59*	84.9	15.1	18.8	12.6	29.1	39.5	100
60	78.8	21.2	13.3	9.2	26.4	51.1	100
61**	67.6	32.4	12.7	10.3	26.0	51.0	100
61*	68.6	31.4	20.2	14.9	25.6	39.3	100
62	67.0	33.0	18.7	22.8	30.0	28.5	100
63	74.6	25.4	19.4	33.7	25.3	21.6	100
64	78.8	21.2	20.6	36.0	23.3	20.1	100
65	44.5	55.5	22.6	28.1	23.3	26.0	100
66	53.5	46.5	24.7	35.6	19.7	20.0	100
67	57.7	42.3	26.3	35.1	18.6	20.0	100
68	50.9	49.1	32.3	32.0	16.7	19.0	100
69	51.4	48.6	31.8	29.8	17.1	21.3	100
70	53.2	46.8	33.2	33.2	18.1	15.5	100
71	51.2	48.8	36.1	30.1	16.9	16.9	100
72	56.4	43.6	26.0	31.4	17.9	24.7	100
73	54.2	45.8	31.0	28.6	19.0	21.4	100
74	29.6	70.4	26.8	31.7	16.9	24.6	100
75**	26.2	73.8	20.6	44.4	16.4	18.6	100
76			18.7	49.5	16.9	14.9	100
77			18.8	46.5	16.9	17.7	100

* Three months

** Nine months

Source : Calculated from Table A.1 .

Table A.3 Annual Government Expenditure in the Economic Development Programmes, 1951 - 1975

I.D. Thousand

Sector / Year	Agriculture			Industry	Transport and communic-ation	Building and services	Total
	Reservoirs, irrigation, drainage	Agricul-tural services	Total				
1951	841	155	996	-	908	1,127	3,031
52	2,491	274	2,765	81	2,307	2,471	7,624
53	4,795	1,231	6,026	461	2,238	3,228	11,953
54	8,519	1,048	9,567	2,045	4,949	4,030	20,591
55	11,963	458	12,421	2,883	9,916	6,060	31,280
56	12,177	912	13,089	5,039	11,097	13,209	42,434
57	12,855	1,113	13,968	8,591	14,200	19,989	56,748
58	11,438	1,466	12,904	11,880	9,555	17,152	51,491
59**	6,477	1,452	7,929	3,872	12,403	16,053	40,257
59*	2,289	342	2,631	971	1,202	4,320	9,124
60	9,571	1,238	10,809	5,681	7,922	21,182	45,594
61**	4,945	2,252	7,197	5,130	12,008	21,358	45,693
61*	2,195	484	2,679	1,942	2,110	8,838	15,569
62	3,832	2,151	5,983	10,327	15,792	26,383	58,485
63	2,648	1,864	4,512	9,530	18,320	21,222	53,584
64	4,061	2,672	6,733	16,516	18,860	30,594	72,703
65	3,206	2,791	5,997	15,128	12,443	16,194	49,762
66	3,732	4,767	8,499	29,288	15,099	12,047	64,933
67	6,962	4,062	11,024	23,722	13,600	13,285	61,631
68	8,067	5,177	13,244	18,164	9,924	12,956	54,288
69	9,173	8,333	17,506	17,592	10,092	11,831	57,021
70			14,058	21,145	7,406	9,894	52,503
71			49,310	35,917	16,963	17,605	119,795
72			29,276	22,212	19,864	16,717	88,069
73			37,786	66,360	27,576	36,471	168,193
74			78,043	184,075	105,631	90,624	458,373
75*			99,903	290,175	138,024	101,056	629,158

* Three months

** Nine months

Source : As in Table A.1

Table A.4 Distribution of Annual Governmental Expenditure According to Economic Sectors

Sector / Year	Agriculture: Reservoirs irrigation drainage	Agriculture: Agricul-tural services	Agriculture: Total	Industry	Transport and communic-ation	Building and services	Total
1951	84.4	15.6	32.8	-	30.0	37.3	100
52	90.1	9.9	36.3	1.1	30.2	32.4	100
53	79.6	20.4	50.4	3.9	18.7	27.0	100
54	89.1	10.9	46.4	10.0	24.0	19.6	100
55	96.3	3.7	39.7	9.2	31.7	19.4	100
56	93.0	7.0	30.8	11.9	26.2	31.1	100
57	92.0	8.0	24.6	15.1	25.0	35.3	100
58	88.6	11.4	25.1	23.1	18.5	33.3	100
59**	81.7	18.3	19.7	9.6	30.8	39.9	100
59*	87.0	13.0	28.8	10.6	13.2	47.4	100
60	88.5	11.5	23.7	12.4	17.4	46.5	100
61**	68.7	31.3	15.7	11.2	26.3	46.8	100
61*	81.9	18.1	17.2	12.5	13.5	56.8	100
62	64.0	36.0	10.2	17.7	27.0	45.1	100
63	58.7	41.3	8.4	17.8	34.2	39.6	100
64	60.3	39.7	9.3	22.7	26.0	42.0	100
65	53.5	46.5	12.1	30.4	25.0	32.5	100
66	43.9	56.1	13.1	45.1	23.3	18.5	100
67	63.2	36.9	17.9	38.5	22.0	21.6	100
68	60.9	39.1	24.4	33.4	18.3	23.9	100
69	52.4	47.6	30.7	30.9	17.7	20.7	100
70			26.8	40.3	14.1	18.8	100
71			41.2	29.9	14.2	14.7	100
72			33.2	25.2	22.6	19.0	100
73			22.5	39.4	16.4	21.7	100
74			17.0	40.2	23.0	19.8	100
75**			15.9	46.1	21.9	16.1	100

* Three months

** Nine months

Sources : Calculated from Table A.3

Table A.5 Annual Expenditure Efficiency in Economic Sectors, 1951 - 75 (%)

Sector / Year	Agriculture			Industry	Transport and communication	Building and services	Total
	Reservoirs irrigation drainage	Agricultural services	Total				
1951	27.8	34.4	28.7		34.4	37.2	33.0
52	35.1	21.1	32.9	27.0	48.1	65.0	38.1
53	44.2	57.3	46.4	9.2	41.8	72.5	43.0
54	71.3	43.7	66.7	34.1	83.2	86.7	66.5
55	84.8	53.3	83.0	70.0	61.7	71.2	71.6
56	47.8	33.8	46.4	29.6	54.8	84.1	52.3
57	46.1	41.2	45.6	53.7	48.5	80.6	56.4
58	40.9	63.7	42.6	108.0	28.0	73.9	52.2
59**	21.4	63.1	24.4	43.0	56.1	71.8	46.8
59*	18.6	15.6	18.2	9.9	5.4	14.2	11.8
60	67.0	32.1	59.6	45.2	21.9	30.2	33.3
61**	56.7	53.9	55.8	49.1	45.8	41.5	45.2
61*	16.4	7.9	13.7	13.5	8.5	23.2	16.1
62	28.4	32.3	29.6	41.9	48.7	85.7	54.1
63	15.6	32.3	19.8	24.1	61.5	83.4	45.6
64	20.9	51.1	27.3	38.4	67.6	127.4	60.8
65	27.9	19.5	23.2	47.1	46.8	54.7	43.6
66	23.6	34.7	28.8	68.8	64.1	50.6	54.4
67	40.5	32.2	37.0	59.6	64.8	58.6	54.4
68	39.7	26.4	33.2	45.9	47.9	55.1	43.9
69	79.6	76.5	78.1	83.8	84.1	78.9	81.0
70			50.2	75.5	48.5	76.1	62.3
71			82.2	71.8	60.6	62.9	72.2
72			126.1	79.3	124.2	76.0	98.7
73			58.1	110.6	68.9	81.0	80.1
74			41.1	81.8	88.0	51.8	64.6
75*			48.1	64.8	83.2	53.8	62.3

* Three months

** Nine months

Source : Calculated from Tables A.1 and A.3.

Appendix B, Table B.1 Land Utilization in Iraq by Province in 1958/59 (DONUMS)

Province	Arable Land		Fallow Land		Perman-ent crops	Pastures	Fodder crops	Forests	Total area
	1956/57	1957/58	1956/57	1957/58					
Nineveh	3,494,073	3,554704	3,433,252	3,381,954	50,300	27,764	9	3,046	7,017,777
Arbil	1,259,428	1,252,692	1,076,179	1,085,350	18,434	32,315	2,056	4,428	2,395,275
Sulaimaniya	852,349	885,655	479,524	452,228	21,768	16,666	-	6,636	1,382,953
Kirkuk	1,734,259	1,759,659	1,745,439	1,722,319	3,222	3,267	-	388	3,488,855
Total Northern Region	7,340,109	7,452,710	6,734,394	6,641,851	93,724	80,012	2,065	14,498	14,284,860
Diala	1,543,667	1,539,127	1,294,266	1,302,577	69,217	25,372	27	695	2,937,015
Baghdad	1,242,444	1,253,069	880,975	875,006	45,712	12,028	29,382	280	2,215,477
Anbar	264,835	270,602	162,852	162,102	20,715	610	2,569	205	456,803
Kerbela	77,466	73,753	61,877	65,421	48,214	476	1,179	-	189,043
Babil	737,518	751,130	563,502	563,060	121,286	370	3,906	-	1,439,752
Total Central Region	3,865,930	3,887,681	2,963,472	2,968,166	305,144	38,856	37,063	1,180	7,238,090
Al-Qadisiya	1,186,479	1,260,333	967,523	905,622	106,290	3,106	954	1,165	2,277,470
Wasit	1,164,710	1,710,271	1,233,837	1,230,272	14,874	5	-	66	2,955,488
Maysan	804,123	789,696	835,369	843,587	16,906	7,586	1,180	-	1,658,955
Thi-Qar	1,297,933	1,306,109	645,421	637,083	45,252	91,990	2,586	-	2,083,020
Basrah	90,806	91,506	47,595	48,556	167,741	18,199	1,207	1,385	328,594
Total Southern Region	4,544,051	5,157,915	3,729,745	3,665,120	351,063	120,886	5,927	2,616	9,303,527
Grand Total	15,750,090	16,498,306	13,427,611	13,275,137	749,931	239,754	45,055	18,294	30,826,477

Source: Ministry of Planning (1961) : Results of The Agricultural and Livestock Census in Iraq for the Year 1958-59, Baghdad, Iraq.

Appendix B, Table B.2 Land Utilization in 1970 in Iraq (DONUMS)

Province	Arable land	Permanent crops	Permanent pasture	Forest	Other lands	Total area
Nineveh	6,894,501	36,663	27,960	6,965	100,710	7,066,799
Arbil	1,644,248	15,934	36,721	9,271	37,345	1,743,519
Sulaimaniya	634,458	19,722	7,770	14,162	17,663	693,775
Kirkuk	2,850,975	3,644	617	3,596	66,920	2,925,752
Total Northern Region	12,024,182	75,963	73,068	33,994	222,638	12,429,845
Diala	1,555,638	55,929	2,783	702	278,359	1,893,411
Baghdad	1,209,884	74,492	1,563	2,469	345,900	1,634,308
Anbar	277,639	20,832	2,035	1,701	82,353	384,560
Kerbela	112,475	52,834	378	27	30,355	196,069
Babil	759,014	109,439	3,488	2,213	287,904	1,162,058
Total Central Region	3,914,650	313,526	10,247	7,112	1,024,871	5,270,406
Al-Qadisiya	891,978	54,732	3,886	77	418,089	1,368,762
Wasit	1,364,285	12,636	1,843	1,706	419,231	1,799,701
Maysan	468,715	5,618	1,298	10	184,743	660,384
Thi-Qar	678,992	24,288	58,776	54	426,825	1,188,935
Basrah	50,663	119,235	8,080	247	30,479	208,704
Total Southern Region	3,454,633	216,509	73,883	2,094	1,479,367	5,226,486
Grand Total	19,393,465	605,998	157,198	43,200	2,726,876	22,926,737

Source : Ministry of Planning (1973) : Results of the 1971 Census of Agriculture, Baghdad, Iraq, Table 8, p.37.

Appendix B, Table B.3 Farm Population by Province in 1958/59*

Provinces	Labour force	No. of people supported by farmers	Farmers paid in kind	Farmers paid in cash	Tot. Farm Population
Ninevah	205,957	237,339	29,673	4,076	443,296
Arbil	77,327	110,038	12,017	5,207	187,365
Sulaimaniyia	116,823	59,444	2,853	2,622	176,267
Kirkuk	100,479	117,061	7,677	12,657	217,540
Total Northern Region	500,586	523,882	52,220	24,562	1,024,468
Diala	101,869	101,766	19,465	1,276	203,635
Baghdad	160,978	79,413	23,165	3,287	240,391
Anbar	53,171	63,837	853	527	117,008
Kerbela	23,867	21,068	406	-	44,935
Babil	124,086	82,888	26,571	1,678	206,974
Total Central Region	463,971	348,972	70,460	6,768	812,943
Al Qadisiya	201,120	125,708	64,718	917	326,828
Wasit	94,621	38,762	25,049	374	133,383
Maysan	158,638	72,613	53,829	996	231,251
Thi-Qar	74,528	255,671	20,532	1,918	330,199
Basrah	96,919	64,466	27,269	4,951	161,385
Total Southern Region	625,826	557,220	191,397	9,156	1,183,046
Grand Total	1,590,383	1,430,074	314,077	40,486	3,020,457

* To obtain the total farm population, the total number of labour force must be added to the number of people supported by farmers.

Source : Ministry of Planning (1961) : Results of The Agricultural and Livestock Census in Iraq for 1958/59, Baghdad, Iraq, (Arabic)

Appendix B, Table B.4 Farm Population by Province in 1971

Province	Holders		Hired Workers		Total	
	No. of House-holds	Popul-ation	No. of House-holds	Popul-ation	No. of House-holds	Farm Popul-ation
Nineveh	99,983	629,290	228	1,255	100,211	630,545
Arbil	37,331	220,611	115	595	37,446	221,206
Sulaimaniya	47,971	264,235	151	778	48,122	265,013
Kirkuk	43,675	264,068	413	2,495	44,088	266,563
Total Northern Region	228,960	1,378,204	907	5,123	229,867	1,383,327
Diala	34,450	256,706	4,307	29,756	38,757	286,462
Baghdad	43,132	329,784	9,805	63,649	52,937	393,433
Anbar	18,554	154,479	1,189	8,979	19,743	163,458
Kerbela	12,848	88,159	1,884	10,520	14,732	98,679
Babil	39,759	282,886	2,574	16,755	42,333	299,641
Total Central Region	148,743	1,112,014	19,759	129,659	168,502	1,241,673
Al-Qadisiya	43,175	264,914	8,835	52,600	52,010	317,514
Wasit	33,830	193,132	4,719	27,379	38,549	220,511
Maysan	41,987	215,918	841	5,539	42,828	221,457
Thi-Qar	62,740	340,235	206	1,268	62,946	341,503
Basrah	30,990	242,487	736	4,573	31,726	247,060
Total Southern Region	212,722	1,256,686	15,337	91,359	228,059	1,348,045
Grand Total	590,425	3,746,904	36,003	226,141	626,428	3,973,045

Source: Ministry of Planning (1973) : Results of the 1971 Census of Agriculture, Baghdad, Iraq, Table 40, page 136.

Appendix B Table B.5 Agricultural Employment by Province in 1958/59 and 1971

Province	Agricultural Employment in 1958/59	Agricultural Employment 1971
Nineveh	205,957	353,946
Arbil	77,327	110,252
Sulaimanya	116,823	166,510
Kirkuk	100,479	118,599
Total Northern Region	500,586	749,307
Diala	101,869	145,674
Baghdad	160,978	190,904
Anbar	33,171	78,952
Kerbela	23,867	58,217
Babil	124,086	173,746
Total Central Region	463,971	647,493
Al-Qadisiya	201,120	143,406
Wasit	94,621	113,124
Maysan	158,638	121,410
Thi-Qar	74,528	205,342
Basrah	96,919	130,481
Total Southern Region	625,826	713,763
Grand Total	1,590,383	2,110,563

Sources : 1. Ministry of Planning (1961) : Results of The Agricultural and Livestock Census in Iraq for 1958-59, Baghdad, Iraq, (Arabic)

2. Ministry of Planning (1973) : Results of The 1971 Census of Agriculture, Baghdad, Iraq, Table 39 , page 131.

Appendix C, Table C.1 The Distribution of Land Tenure in Agricultural Holdings in each Province in 1958/59

(DONUMS)

Province	*Tapu*	%	*Lazma*	%	*Miri-sirf*	%	*Waqf*	%	*Mulk*	%	Unsettled Land Title	%	Total
Nineveh	3,861,116	30.93	1,429,889	13.51	1,624,451	24.08	63,380	14.43	1,530	0.59	67,097	4.08	7,047,463
Arbil	1,191,820	9.55	774,704	7.32	161,649	2.40	1,175	0.27	3,229	1.25	264,528	16.09	2,397,105
Sulaimaniya	1,062,489	8.51	64,099	0.61	160,948	2.39	370	0.08	17,253	6.69	92,735	5.64	1,397,894
Kirkuk	1,925,836	15.43	936,671	8.85	538,504	7.98	69,421	15.81	985	0.38	25.853	1.57	3,497,270
Northern Reg.	8,041,261	64.42	3,205,363	30.29	2,485,552	36.85	134,346	30.59	22,997	8.91	450,213	27.38	14,339,732
Diala	1,143,366	9.16	1,305,186	12.33	349,643	5.18	224,857	51.21	68,671	26.62	-	-	3,091,723
Baghdad	217,450	1.74	1,165,480	11.00	948,591	14.07	27,872	6.35	65,068	25.22	-	-	2,424,461
Anbar	123,041	0.99	357,941	3.38	31,264	0.46	2,324	0.53	6,858	2.66	-	-	521,428
Kerbela	164,216	1.32	39,352	0.37	2,375	0.04	843	0.19	13,966	5.41	-	-	220,752
Babil	582,850	4.67	840,616	7.94	91,308	1.35	27,186	6.19	2,891	1.12	-	-	1,544,851
Central Reg.	2,230,923	17.88	3,708,575	35.02	1,423,181	21.10	283,082	64.47	157,454	61.03	-	-	7,803,215
Wasit	724,078	5.80	1,573,697	14.86	403,533	5.98	173	0.04	-	-	-	-	2,701,481
Maysan	35,525	0.28	58,505	0.55	2,059,753	30.54	104	0.02	450	0.17	-	-	2,154,337
Thi-Qar	1,011,047	8.10	80,187	0.76	-		-	-	426	0.17	1,169,010	71.10	2,260,670
Al-Qadisiya	269,310	2.16	1,929,216	18.22	326,466	4.84	-	-	99	0.04	7,200	0.44	2,532,291
Basrah	169,444	1.36	32,133	0.30	45,805	0.68	21,370	4.87	76,572	29.68	17,764	1.08	363,088
Southern Reg.	2,209,404	17.70	3,673,738	34.69	2,835,557	42.04	21,647	4.93	77,547	30.06	1,193,974	72.62	10,011,867
Grand Total	12,481,588	100	10,587,676	100	6,744,290	100	439,075	100	257,998	100	1,644,187	100	32,154,814

Source : Ministry of Planning (1961) : Results of the Agricultural and Livestock Census in Iraq for the year 1958/59, Baghdad, Iraq, (in Arabic).

Appendix C, Table C.2   The Distribution of Land Tenure in Agricultural Holdings in each Province in 1971 **(DONUMS)**

Province	*Tapu*	%	*Lazma*	%	*Miri-Sirf* *	%	*Mulk*	%	Rented	%	Owned from Agrarian Law	%	Tot.Holdings in provinces
Nineveh	871,414	28.80	740,543	19.69	218,888	14.37	650,083	39.14	3,430,099	36.54	1,166,875	32.54	7,077,902
Arbil	327,369	10.82	305,400	8.12	32,765	2.15	273,043	16.44	689,056	7.34	116,976	3.26	1,744,609
Sulaimaniya	58,046	1.92	21,161	0.56	41,768	2.74	194,964	11.74	320,261	3.41	57,648	1.61	693,848
Kirkuk	559,836	18.50	493,712	13.13	277,626	18.23	68,297	4.11	1,201,450	12.80	326,495	9.10	2,927,416
Northern Region	1,816,665	60.04	1,560,816	41.5	571,047	37.49	1,186,387	71.43	5,640,866	60.09	1,667,994	46.51	12,443,775
Diala	256,006	8.46	438,830	11.67	32,815	2.16	145,743	8.78	954,648	10.17	64,929	1.81	1,892,971
Baghdad	158,867	5.25	437,520	11.63	153,596	10.08	77,648	4.68	479,602	5.11	326,948	9.12	1,634,181
Anbar	107,807	3.56	130,266	3.46	19,359	1.27	19,218	1.16	72,218	0.77	35,628	0.99	384,496
Kerbela	43,802	1.45	36,853	0.98	32,469	2.13	24,322	1.46	36,894	0.39	21,790	0.61	196,130
Babil	139,246	4.60	250,245	6.65	103,020	6.76	32,814	1.98	218,374	2.33	418,692	11.68	1,162,391
Central Region	705,728	23.32	1,293,714	34.39	341,259	22.40	299,745	18.06	1,761,736	18.77	867,987	24.21	5,270,169
Wasit	241,558	7.98	227,705	6.05	132,061	8.67	28,461	1.71	760,111	8.10	413,104	11.52	1,803,000
Maysan	24,277	0.80	26,360	0.70	52,516	3.45	18,033	1.09	230,418	2.45	309,062	8.62	660,666
Thi-Qar	28,864	0.95	71,417	1.90	322,657	21.19	15,079	0.90	554,126	5.90	196,951	5.49	1,189,094
Al-Qadisiya	179,866	5.94	573,973	15.26	61,494	4.04	70,175	4.23	356,661	3.80	127,088	3.54	1,369,257
Basrah	28,953	0.96	7,623	0.20	41,992	2.76	42,874	2.58	82,950	0.88	4,091	0.11	208,483
Southern Region	503,518	16.63	907,078	24.11	610,720	40.11	174,622	10.51	1,984,266	21.13	1,050,296	29.28	5,230,500
Total	3,025,911	100	3,761,608	100	1,523,026	100	1,660,754	100	9,386,868	100	3,586,277	100	22,944,444

* Includes operated on a squatter basis, and other holdings managed by other form
Source: Ministry of Planning (1973) : Results of 1971 Census of Ag.Baghdad, Iraq, Table 6 and 6A,pp.28-31.

Appendix C, Table C.3 The Size Distribution of Agricultural Holdings in 1958/59

Size of Holdings	No. of Holdings	%	Area (Donums)	%
< 1	23,089	9.12	8,599	0.03
1 < 4	50,021	19.80	93,722	0.03
4 < 10	40,475	15.98	243,004	0.76
10 < 20	30,431	12.01	411,152	1.30
20 < 30	18,038	7.12	419,151	1.30
30 < 40	12,907	5.10	423,580	1.32
40 < 50	9,673	3.82	417,601	1.30
50 < 60	7,787	3.07	411,903	1.30
60 < 80	13,422	5.30	892,184	2.80
80 < 100	8,675	3.42	751,769	2.34
100 < 120	8,087	3.19	847,351	2.64
120 < 150	5,810	2.29	756,918	2.35
150 < 200	7,103	2.80	1,184,728	3.70
200 < 300	6,224	2.46	1,439,130	4.50
300 < 400	2,788	1.10	921,494	2.90
400 < 500	1,496	0.59	649,391	2.02
500 < 600	957	0.38	508,787	1.60
600 < 800	1,209	0.48	819,561	2.55
800 < 1,000	750	0.30	664,083	2.10
1,000 < 1,500	1,179	0.46	1,446,209	4.50
1,500 < 2,000	653	0.26	1,113,981	3.46
2,000 < 4,000	1,293	0.51	3,583,931	11.15
4,000 < 10,000	835	0.33	4,966,391	15.45
10,000 < 20,000	224	0.09	3,030,773	9.43
20,000 < 50,000	95	0.04	2,998,607	9.33
50,000 < 100,000	25	0.01	1,725,988	5.40
> 100,000	8	0.003	1,424,825	4.43
Total	253,254	100	32,154,813	100

Source : Ministry of Planning (1961) : Results of the Agricultural and Livestock Census in Iraq for the year 1958/59, Baghdad, Iraq, Table 2, p.7, (in Arabic).

Appendix C, Table C.4 The Size Distribution of Agricultural Holdings in 1971

Size of Holdings	No. of Holdings	%	Area (Donums)	%
< 1	6,995	1.30	3,536	0.02
1 < 4	60,217	11.17	129,027	0.56
4 < 10	89,815	16.66	561,026	2.45
10 < 20	83,339	15.46	1,097,053	4.79
20 < 30	60,863	11.29	1,377,976	6.01
30 < 40	65,814	12.21	2,085,707	9.10
40 < 50	51,219	9.50	2,135,648	9.31
50 < 60	19,568	3.63	1,018,478	4.44
60 < 80	38,867	7.21	2,530,834	11.04
80 < 100	14,240	2.64	1,217,842	5.31
100 < 120	14,537	2.70	1,497,949	6.53
120 < 150	17,410	3.23	2,141,507	9.34
150 < 200	6,854	1.27	1,111,402	4.85
200 < 300	4,089	0.76	941,287	4.11
300 < 400	1,719	0.32	560,845	2.45
400 < 500	864	0.16	369,430	1.61
500 < 600	513	0.10	268,537	1.17
600 < 800	575	0.11	381,393	1.66
800 < 1,000	302	0.06	266,038	1.16
1,000 < 1,300	553	0.10	578,869	2.52
1,300 < 1,600	130	0.02	186,214	0.81
1,600 < 2,000	104	0.02	182,715	0.80
> 2,000	453	0.08	2,283,432	9.96
Total	539,040	100	22,926,745	100

Source : Ministry of Planning (1975) : Annual Abstract of Statistics, 1974, Baghdad, Iraq, Table 28, p.56.

APPENDIX D, Table D.1 The Progress of the Agricultural Cooperative under the Land Reform Law Between 1961-1975 in Iraq

Province	1961		1962		1963		1964		1965		1966		1967		1968	
	No.of Coops	Mem-bers	No.of coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers
Nineveh	-	-	2	694	7	1,939	19	3,032	28	4,367	40	5,151	46	6,334	62	6,889
Arbil	-	-	-	-	-	-	9	880	10	1,291	12	1,407	21	2,872	26	4,034
Sulaimaniya	2	20	7	524	7	524	7	524	7	699	7	699	9	1,023	21	1,718
Kirkuk	2	158	2	158	2	158	9	657	16	1,841	24	2,415	26	4,106	34	3,792
Total of Northern Region	4	178	11	1,376	16	2,621	44	5,093	61	8,198	83	9,672	102	14,335	143	16,433
Diala	1	40	2	177	2	177	7	923	12	1,350	16	2,277	21	3,762	30	4,231
Baghdad	-	-	4	530	4	530	38	3,204	45	5,299	51	5,786	55	7,414	55	7,894
Anbar	10	1,669	14	2,228	15	2,299	30	4,043	8	378	19	660	30	1,676	28	1,822
Kerbela	-	-	1	26	1	26	8	484	17	1,998	17	1,998	17	2,303	17	2,347
Babil	2	234	2	234	6	810	13	1,054	34	4,966	44	6,574	39	5,376	40	6,047
Total of Central Region	13	1,943	23	3,195	28	3,842	96	9,708	116	13,991	147	17,295	162	20,531	170	22,341
Al-Qadisiya	-	-	2	453	3	652	13	1,699	23	2,831	29	3,557	32	4,707	42	5,331
Wasit	-	-	10	1,784	11	1,922	43	6,214	47	7,346	51	7,885	51	9,232	79	10,314
Maysan	-	-	2	542	2	542	18	702	26	2,123	34	2,868	36	4,684	45	6,580
Thi-Qar	-	-		-	-	-	2	20	14	953	14	953	10	891	14	1,087
Basrah	-	-	-	-	2	264	7	314	10	771	10	771	10	1,056	10	1,233
Total of Southern Region	-	-	14	2,779	18	3,380	83	8,949	120	14,024	138	16,034	139	20,570	190	24,545
Iraq	17	2,112	48	7,350	62	9,843	223	23,750	297	36,213	368	43,001	403	55,436	503	63,319

APPENDIX D, Table D.1 (Cont.)

Province	1969		1970		1971		1972		1973		1974		1975	
	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers	No.of Coops	Mem-bers
Nineveh	96	11,137	103	14,601	107	16,905	152		179		193	29,699	266	32,918
Arbil	27	4,798	33	6,326	37	6,479	39		52		52	11,264	104	12,697
Sulaimaniya	21	2,295	32	4,064	34	5,059	42		61		60	8,471	135	12,302
Kirkuk	39	4,595	58	6,815	60	7,694	70		101		103	14,278	113	15,742
Total of Northern Region	183	22,825	226	31,806	238	36,137	303		393		408	63,712	618	73,659
Diala	71	8,901	43	8,217	45	9,261	42		67		74	14,702	79	15,865
Baghdad	40	6,531	84	12,025	98	15,298	116		141		163	20,718	170	21,656
Anbar	31	1,954	32	2,404	32	2,723	50		64		68	4,790	77	5,342
Kerbela	18	2,515	22	2,692	22	3,491	25		35		39	6,199	45	6,878
Babil	64	7,821	65	10,441	54	9,024	84		112		123	19,811	124	21,260
Total of Central Region	224	27,722	246	35,779	251	39,797	317		419		467	66,220	495	71,001
Al-Qadisiya	74	7,678	81	10,118	87	10,688	103		131		141	16,567	158	17,821
Wasit	91	12,690	109	16,826	110	21,486	109		157		155	28,933	156	28,801
Maysan	56	7,892	79	9,143	81	13,114	106		115		116	21,773	113	24,547
Thi-Qar	27	1,815	48	4,849	52	11,602	52		64		64	14,989	74	16,585
Basrah	12	1,452	16	1,951	18	2,289	25		35		35	5,529	38	7,230
Total of Southern Region	260	31,527	333	42,887	348	59,179	395		502		511	87,791	539	94,984
Iraq	667	82,074	805	110,472	837	135,113	1,015	146,630	1,314	201,490	1,386	217,723	1,652	239,644

Source: Ministry of Planning, Series of Annual Abstract of Statistics,1961-1975,Baghdad, Iraq.

Appendix E, Table E.1

The Estimated Net Area Cultivated with Wheat Distributed According to Seed Varieties and Area Fertilized (100 donums)

Province	1970/71				1971/72										1972/73									
	Mexi-pak	Main Local vari-eties	Oth-ers	Total	Mexipak		Other Impor-ted variet-ies		Main local varieties		Others		Total		Mexipak		Other Impor-ted variet-ies		Main local varieties		Others		Total	
					F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF	F	UF
Nineveh	113	1,781	9,471	11,365	-	4,805	-	15,063	-	11,152	-	-	-	31,020	-	1,790	-	5,430	-	2,511	-	152	-	9,883
Arbil	107	2,621	1,243	3,971	-	250	-	2,745	-	2,964	-	-	-	5,959	-	173	-	1,294	-	4,423	-	-	-	5,890
Sulaimaniya	52	1,548	10	1,610	-	724	-	634	-	1,656	-	75	-	3,089	-	695	-	374	-	1,487	-	127	-	2,683
Kirkuk	177	1,369	2,773	4,319	-	498	-	7,372	-	5,292	-	3,942	-	17,104	-	638	-	870	-	8,786	-	25	-	10,319
Northern Region	449	7,319	13,497	21,265	-	6,277	-	25,814		21,064	-	4,017	-	57,172	-	3,296	-	7,968	-	17,207	-	304	-	28,775
Diala	229	1,140	1,600	2,969	345	410	21	254	4	1,685	1	481	371	2,830	59	658	-	17	-	630	-	1,152	59	2,457
Baghdad	1,821	672	274	2,767	1,304	2,774	108	527	14	312	-	224	1,426	3,837	627	3,169	3	249	-	122	-	-	630	3,540
Anbar	118	140	138	396	275	191	3	168	24	76	34	127	336	562	183	537	3	75	1	40	9	20	196	672
Kerbela	45	38	-	83	17	87	-	-	-	-	-	-	17	87	21	107	-	-	-	-	-	-	21	107
Babil	859	291	449	1,599	527	929	1	69	16	39	42	127	586	1,164	699	1,084	4	57	-	-	-	43	703	1,184
Central Region	3,072	2,281	2,461	7,814	2,468	4,391	133	1,018	58	2,112	77	959	2,736	8,480	1,589	5,555	10	398	1	792	9	1,215	1,609	7,960
Al-Qadisiya	432	1,492	69	1,993	125	1,987	-	3	4	393	-	4	129	2,387	43	1,830	-	3	-	97	-	43	43	1,973
Wasit	1,612	486	2,617	4,715	816	1,347	53	187	5	381	-	423	874	2,338	344	2,030	9	771	-	325	2	121	355	3,247
Thi-Qar	478	14	724	1,216	478	471	-	47	1	446	-	7	479	971	332	697	-	9	-	275	-	29	332	1,010
Maysan	329	-	388	717	205	151	-	-	1	1	1	273	207	425	14	546	-	-	-	179	-	110	14	835
Basrah	212	-	-	212	-	386	-	-	-	-	-	-	-	386	5	81	-	-	-	-	-	-	5	81
Southern Region	3,063	1,992	3,798	8,853	1,624	4,342	53	237	11	1,221	1	707	1,689	6,507	738	5,184	9	783	-	876	2	303	749	7,146
Total	6,584	11,592	19,756	37,932	4,092	15,010	186	27,069	69	24,397	78	5,683	4,425	72,159	2,327	14,035	19	9,149	1	18,875	11	1,822	2,358	43,881

Source: Ministry of Planning : Annual Abstract of Statistics 1971, 1972, 1973, Baghdad, Iraq. ,F : Fertilized , UF : Unfertilized.

Appendix E, Table E.2 Quantities of Imported Chemical Fertilizers

Year	Metric tons	Year	Metric tons
1957	1,363	1966	17,585
1958	4,353	1967	31,460
1959	1,643	1968	36,370
1960	4,784	1969	62,830
1961	6,413	1970	64,873
1962	8,502	1971	34,372
1973	10,308	1972	48,233
1964	11,326	1973	25,062
1965	13,010		

Sources: Al-Anni, K. (1972) : Iraq Agricultural Geography, Arab League, Cairo, Table 21, p.138, (in Arabic).

Rashid, M.N. & Al-Bandar, T. (1972) : The Chemical Fertilizers in Iraq, Ministry of Planning, Baghdad, Iraq, Table 11, p.42, (in Arabic).

Ministry of Planning, Annual Foreign Trade of 1971, 1972 and 1973, Baghdad, Iraq.

Appendix E, Table E.3 Number of Holdings and Fertilizers Use by Area in 1970/71

Province	Organic fertilizers			Chemical fertilizers		
	No. of Holdings	Quantity m.(Tons)	Area (Donums)	No. of Holdings	Quantity m.(Tons)	Area (Donums)
Ninevah	14,438	102,862	69,598	6,447	3,524	53,408
Arbil	7,462	28,838	41,724	682	374	8,172
Sulaimanya	11,455	29,478	41,904	6,388	1,118	27,373
Kirkuk	3,021	33,802	16,873	1,088	717	15,676
Northern Region	36,376	194,980	170,099	14,605	5,733	104,629
Diala	11,289	87,038	43,121	7,812	3,211	54,569
Baghdad	12,133	148,242	106,404	20,857	19,728	303,572
Anber	3,535	24,317	14,884	3,843	2,114	38,983
Kerbela	5,371	64,067	30,326	8,253	4,966	80,619
Babil	17,400	129,500	91,407	17,934	9,522	151,275
Central Region	49,728	453,164	286,142	58,699	39,541	629,018
Al-Qadisya	275	5,212	4,905	10,493	9,961	159,476
Wasit	2,749	25,231	18,065	6,720	4,806	103,172
Thi-Qar	526	2,759	1,802	1,818	413	57,798
Maysan	52	338	981	9,164	1,197	46,116
Basrah	8,248	44,039	22,701	8,751	2,152	27,020
Southern Region	11,850	77,579	48,454	36,946	18,529	393,582
Iraq	97,954	725,723	504,695	110,250	63,803	1,127,229

Source: Ministry of Planning (1973) : Results of 1971 Census of Agriculture, part one, Baghdad, Iraq, Table 47, p.161.

Appendix E, Table E.4 The Estimated Area Under Wheat Production (Fertilized and Unfertilized) (100 donums)

Province	1971/72			1972/73			1973/74		
	Fertilized	Un-fertilized	Total	Fertilized	Un-fertilized	Total	Fertilized	Un-fertilized	Total
Ninevah	-	31,020	31,020	-	9,883	9,883	-	27,926	27,926
Arbil	-	5,959	5,959	-	5,890	5,890	-	6,988	6,988
Sulaimaniya	-	3,089	3,089	-	2,683	2,683	-	2,204	2,204
Kirkuk	-	17,104	17,104	-	10,319	10,319	61	12,003	12,064
Northern Region	-	57,172	57,172	-	28,775	28,775	61	49,121	49,182
Diala	371	2,830	3,201	63	2,457	2,520	221	2,592	2,813
Baghdad	1,426	3,837	5,263	630	3,540	4,170	571	2,614	3,185
Anbar	336	562	898	197	672	869	63	698	761
Kerbela	17	87	104	21	107	128	24	47	71
Babil	586	1,164	1,750	703	1,183	1,886	530	1,031	1,561
Central Region	2,736	8,480	11,216	1,614	7,959	9,573	1,409	6,982	8,391
Al-Qadisiya	129	2,387	2,516	43	1,973	2,016	14	1,385	1,399
Wasit	874	2,338	3,212	355	3,247	3,602	722	3,003	3,725
Thi-Qar	479	971	1,450	332	1,010	1,342	230	1,471	1,701
Maysan	207	425	632	14	835	849	31	870	901
Basrah	-	386	386	5	81	86	-	35	35
Southern Region	1,689	6,507	8,196	749	7,146	7,895	997	6,764	7,761
Iraq	4,425	72,159	76,584	2,363	43,880	46,243	2,467	62,867	65,334

Source : Ministry of Planning, Annual Abstract of Statistics, 1972, 1973 and 1974, Baghdad, Iraq.

Appendix E, Table E.5 The Estimated Area Under Barley Production (Fertilized and Unfertilized) (100 donums)

Province	1972/73			1973/74		
	Fertilized	Un-fertilized	Total	Fertilized	Un-fertilized	Total
Nineveh	-	1,882	1,882	-	3,806	3,806
Arbil	-	1,092	1,092	-	1,097	1,097
Sulaimaniya	-	709	709	-	588	588
Kirkuk	-	2,908	2,908	-	3,095	3,095
Northern Region	-	6,591	6,591	-	8,586	8,586
Diala	11	1,853	1,864	34	1,773	1,807
Baghdad	88	1,053	1,141	154	1,607	1,761
Anbar	13	269	282	8	335	343
Kerbela	25	101	126	2	97	99
Babil	104	2,230	2,334	120	1,714	1,834
Central Region	241	5,506	5,747	318	5,526	5,844
Al-Qadisiya	7	1,195	1,202	-	1,055	1,055
Wasit	56	2,807	2,863	99	2,788	2,887
Thi-Qar	-	1,466	1,466	-	1,558	1,558
Maysan	-	633	633	-	808	808
Basrah	-	62	62	-	34	34
Southern Region	63	6,163	6,226	99	6,243	6,342
Iraq	304	18,260	18,564	417	20,355	20,772

Source: Ministry of Planning, Annual Abstract of Statistics, 1973 and 1974, Baghdad, Iraq.

Appendix E, Table E.6 The Estimated Area Under Paddy Production (Fertilized and Unfertilized)

(00 Donums)

Province	1973			1974		
	Fertilized	Un-fertilized	Total	Fertilized	Un-fertilized	Total
Nineveh	1,610	4,040	5,650	-	1,700	1,700
Arbil	-	920	920	340	3,740	4,080
Sulaimaniya	1,280	790	2,070	-	-	-
Kirkuk	500	7,150	7,650	700	30,860	31,560
Northern Region	3,390	12,900	16,290	1,040	36,300	37,340
Diala	-	-	-	-	-	-
Baghdad	-	-	-	1,620	1,030	2,650
Anbar	-	-	-	-	-	-
Kerbela	31,040	-	31,040	137,800	34,550	172,350
Babil	-	60	60	-	-	-
Central Region	31,040	60	31,100	139,420	35,580	175,000
Al-Qadidiya	97,780	8,110	105,890	97,710	5,060	102,770
Wasit	-	-	-	-	-	-
Thi-Qar	-	6,220	6,220	190	116,510	116,700
Maysan	870	90,560	91,430	227,450	585,170	812,620
Basrah	360	510	870	4,250	79,670	83,920
Southern Region	99,010	105,400	204,410	329,600	786,410	11,16,010
Iraq	133,440	118,360	251,800	470,060	858,290	1,328,350

Source : Ministry of Planning, Annual Abstract of Statistics, 1973 and 1974, Baghdad, Iraq.

Appendix E, Table E.7   Chemical Fertilizers Consumption in Iraq

Year	Consumption (MT)
1961/62 - 65/66	2,500
1967/68	9,326
1968/69	10,902
1969/70	14,522
1970/71	17,000*
1971/72	20,246
1972/73	22,670
1973/74	28,669
1974/75	34,442
1975/76	32,700*
1976/77	34,000
1977/78	54,200*

* Unofficial figures

Source : F.A.O. (1979) : Fertilizer Year Book, 1978, Study Series No. 23, Rome, Italy, Table XVI, pp.76-77.

Appendix F, Table F.1 Number of Tractors Sold and Distributed According to Province in Iraq

Province	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Nineveh	62	4	31	107	114	39	101	80	37	7	66	93	350	268	252	274	236	137	174	118	89	12	20	115	22	39
Arbil	-	2	7	17	8	7	21	13	1	8	14	36	52	4	29	30	52	90	75	18	49	20	8	28	2	17
Sulaimaniya	3	-	8	2	3	3	18	2	1	-	21	14	21	12	26	25	91	70	41	19	50	3	2	45	1	19
Kirkuk	12	-	6	25	17	25	14	8	6	5	8	63	158	79	47	55	96	109	165	87	46	40	112	136	16	68
Northern Region	77	6	52	151	142	74	154	103	45	20	109	206	581	363	354	384	475	406	455	242	234	75	142	324	41	143
Diala	4	2	-	5	3	16	13	23	17	6	18	60	63	49	51	77	116	72	100	60	61	67	76	113	66	108
Baghdad	59	27	23	114	54	86	98	93	100	36	208	333	264	217	200	242	308	291	295	272	162	394	414	418	378	560
Anbar	4	-	-	17	12	17	20	7	26	5	39	49	96	65	47	74	74	93	50	93	34	31	80	79	114	130
Kerbela	1	-	3	8	6	2	3	5	2	-	3	12	12	10	10	9	7	6	4	9	19	30	13	26	21	25
Babil	1	4	7	18	8	16	18	20	17	3	35	48	52	67	54	37	53	110	68	56	21	61	62	69	78	95
Central Region	69	33	33	162	83	137	152	148	162	50	303	502	487	408	362	439	558	572	517	490	297	583	645	705	657	918
Al-Qadisiya	8	2	6	22	14	20	34	15	7	1	3	8	3	5	14	11	33	47	23	15	34	28	37	31	39	41
Wasit	12	5	10	5	12	22	28	9	10	2	3	11	20	42	75	92	90	79	63	63	16	37	37	106	24	27
Thi-Qar	-	-	1	-	2	-	5	3	10	-	-	-	1	3	11	12	22	31	6	3	1	5	2	14	15	26
Maysan	-	8	1	2	4	6	3	4	6	-	2	3	2	11	6	37	48	51	18	8	16	20	13	46	39	37
Basrah	1	-	2	1	1	1	5	3	7	-	2	13	2	13	10	6	7	7	1	1	2	4	3	14	8	40
Southern Region	21	15	20	30	33	49	75	34	40	3	10	35	28	74	116	158	200	215	111	90	69	94	92	211	125	171
Iraq	167	54	105	343	258	260	381	285	247	73	422	743	1,096	845	832	981	1,233	1,193	1,083	822	600	752	879	1,240	823	1,232

Source : Ministry of Economics : Annual Abstracts of Statistics, 1950-1958, Baghdad, Iraq.

" Planning " " " 1959-75, " "

Appendix F, Table F.2 Number of Combines Sold and Distributed According to Province in Iraq

Province	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Nineveh	79	72	66	298	116	38	109	239	16	17	12	189	207	174	220	191	65	27	60	91	71	3	82	6	7	41
Arbil	-	5	5	16	-	-	1	10	4	6	-	28	11	15	19	30	26	17	43	36	20	3	20	-	-	-
Sulaimaniya	-	1	4	4	3	-	-	2	-	-	-	4	1	-	2	1	1	3	3	6	4	-	2	1	-	-
Kirkuk	11	17	10	49	3	4	13	33	6	97	-	78	24	20	16	49	26	6	95	71	20	-	52	-	1	-
Northern Region	90	95	85	367	122	42	123	284	26	120	12	299	243	209	257	271	118	53	201	204	115	6	156	7	8	41
Diala	-	-	-	-	-	-	5	2	7	11	-	2	4	-	1	1	7	1	9	13	6	-	8	-	1	-
Baghdad	8	13	8	50	29	14	37	23	32	2	1	35	4	-	3	91	5	9	16	38	29	-	17	4	9	38
Anbar	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	6	-	-	-	2	1	-	6	-	-	-
Kerbela	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	5	1	-	-
Babil	-	-	-	-	-	2	6	-	1	-	-	-	-	-	1	-	-	3	-	-	-	-	20	-	1	-
Central Region	8	13	8	50	29	16	48	25	41	13	1	37	10	-	5	98	12	13	25	53	37	-	56	5	11	38
Al-Qadisiya	-	-	-	1	-	8	34	20	5	1	-	-	-	1	1	1	2	48	13	3	2	2	6	-	-	-
Wasit	-	-	3	3	1	4	8	5	7	-	2	7	-	-	-	10	6	9	1	1	10	7	2	1	-	-
Thi-Qar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Maysan	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Basrah	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Southern Region	-	-	3	4	1	12	43	26	13	1	2	7	-	1	1	11	8	57	14	4	12	9	11	1	-	-
Iraq	98	108	96	421	152	70	214	335	80	134	15	343	253	210	263	380	138	123	240	261	164	15	223	13	19	79

Source : Ministry of Economics : Annual Abstracts of Statistics, 1950-1958, Baghdad, Iraq.
" Planning " " " 1959-75, " "

Appendix F, Table F.3 Number of Ploughs Sold and Distributed According to Province in Iraq

Province	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Nineveh	34	12	12	41	18	18	61	31	11	8	31	60	64	80	115	63	46	36	45	21	18	5	1	60	11	24
Arbil	2	2	1	4	2	5	5	3	1	-	6	10	6	-	3	6	6	19	11	3	4	-	2	21	11	12
Sulaimaniya	-	2	8	2	2	3	18	4	-	-	22	17	17	10	30	24	62	30	20	4	7	-	3	33	1	11
Kirkuk	3	-	4	6	5	4	5	2	1	2	-	2	16	15	18	16	18	16	29	18	3	13	15	92	13	61
Northern Region	39	16	25	53	27	30	89	40	13	10	59	89	103	105	166	109	132	101	105	46	32	18	21	206	36	108
Diala	3	1	-	6	3	11	12	15	23	6	17	51	49	38	40	56	86	55	49	35	32	20	16	88	49	65
Baghdad	72	37	26	71	58	71	76	68	88	33	158	245	230	245	217	250	268	268	194	149	86	165	87	278	314	372
Anbar	3	1	-	12	9	14	20	6	24	4	29	49	88	63	41	68	56	85	38	59	11	14	25	61	1	197
Kerbela	3	-	3	9	4	1	3	3	1	-	2	12	5	10	5	7	4	6	2	3	15	12	3	23	19	16
Babil	3	3	5	15	9	16	17	16	16	1	29	53	47	60	45	34	35	91	59	44	22	57	25	52	82	65
Central Region	84	42	34	113	83	113	128	108	152	44	235	410	419	416	348	415	449	505	342	290	166	268	156	502	465	715
Al-Qadisiya	9	3	4	15	17	16	34	18	6	1	2	10	2	4	8	13	28	39	20	12	21	15	9	28	46	38
Wasit	14	7	7	4	8	18	22	13	11	1	2	10	21	44	56	91	58	71	52	44	4	12	7	97	17	17
Thi-Qar	-	1	2	-	2	-	2	5	-	-	-	-	1	2	7	12	13	18	2	1	-	4	1	11	10	13
Maysan	-	8	1	2	2	6	3	1	5	-	-	3	2	11	6	24	48	31	16	3	3	11	4	38	34	19
Basrah	-	1	1	-	-	1	4	3	8	-	1	7	4	14	8	6	7	10	1	-	-	11	-	10	6	8
Southern Region	23	20	15	21	29	41	65	40	30	2	5	30	30	75	85	146	154	169	91	60	28	53	21	184	113	95
Iraq	146	78	74	187	139	184	282	188	195	56	299	529	552	596	599	670	735	775	538	396	226	339	198	892	614	918

Source : Ministry of Economics : Annual Abstracts of Statistics, 1950-1958, Baghdad, Iraq.

" Planning " " " , 1959-75, " "

Appendix F, Table F.4 Number of Agricultural Implements Sold and Distributed According to Province in Iraq

Province	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Nineveh	30	12	32	80	92	17	81	55	24	21	38	105	88	216	135	93	143	60	25	23	42	-	-	49	21	47
Arbil	1	2	9	17	21	2	26	22	2	12	14	20	29	16	22	23	28	71	15	5	2	-	-	13	2	30
Sulaimaniya	-	2	5	2	-	1	6	8	-	-	14	9	7	6	15	6	13	9	6	7	10	1	-	2	-	116
Kirkuk	9	3	1	28	12	28	16	21	4	3	6	47	110	82	32	35	61	22	61	23	16	1	1	75	7	205
Northern Region	40	19	47	127	125	48	129	106	30	36	72	181	234	320	204	157	245	162	107	58	70	2	1	139	30	398
Diala	1	2	1	4	1	14	29	19	21	7	23	43	86	44	43	47	98	31	38	25	31	5	-	27	32	191
Baghdad	24	53	28	54	55	71	88	115	112	65	205	249	242	162	144	223	215	169	118	152	83	46	62	405	415	1,143
Anbar	1	1	-	6	3	7	4	6	9	1	30	23	32	22	17	20	27	19	9	20	12	-	-	130	71	247
Kerbela	-	1	4	7	-	-	6	2	-	-	4	1	10	6	3	3	7	1	-	3	2	-	-	13	6	45
Babil	1	-	2	9	6	8	7	11	4	1	19	30	23	19	10	13	6	18	6	24	9	3	-	26	83	178
Central Region	27	57	35	80	65	100	134	153	146	74	281	346	393	253	217	306	353	238	171	224	137	54	62	601	607	1,804
Al-Qadisiya	1	1	-	1	2	1	1	6	1	1	6	1	4	-	2	4	7	5	7	-	2	-	-	1	18	92
Wasit	-	5	6	3	4	9	16	1	2	7	29	16	14	26	24	9	19	8	7	2	2	-	-	10	2	59
Thi-Qar	-	-	2	-	1	-	-	1	1	-	2	1	-	-	2	9	8	6	1	-	-	2	-	6	5	57
Maysan	-	-	-	2	2	4	2	3	3	-	3	5	-	9	7	16	16	10	2	1	3	-	-	12	11	54
Basrah	-	-	-	-	-	3	7	5	16	-	1	3	1	6	7	5	3	8	5	-	1	1	-	9	9	33
Southern Region	1	6	8	6	9	17	26	16	23	8	41	26	19	41	42	43	53	37	22	3	8	3	-	38	45	295
Iraq	68	82	90	213	199	165	289	275	199	118	394	553	646	614	463	506	651	437	300	285	215	59	63	778	682	2,497

Source : Ministry of Economics : Annual Abstracts of Statistics, 1950 - 1958, Baghdad, Iraq.
" " Planning : " " " " , 1959 - 1975, " "

Appendix F, F.5 Number of Equipment Owned by Holders of Land or Rights of Usufruct in 1958/59 by Province

Province	Tractors		Combine Harvesters		Threshing Machines
	No.	HP	No.	HP	
Nineveh	254	10,160	55	2,456	56
Arbil	153	6,024	34	1,085	6
Sulaimaniya	30	1,345	5	249	-
Kirkuk	324	11,141	74	1,561	65
Northern Region	761	28,670	168	5,351	127
Diala	139	6,456	15	774	17
Baghdad	503	18,195	55	2,480	12
Anbar	281	9,792	-	-	-
Kerbela	4	160	-	-	-
Babil	157	5,144	-	-	-
Central Region	1,084	39,747	70	3,254	29
Al-Qadisiya	251	9,785	37	1,690	34
Wasit	233	9,404	32	1,928	9
Thi-Qar	4	155	-	-	-
Maysan	65	2,348	-	-	-
Basrah	4	121	-	-	-
Southern Region	557	21,813	69	3,618	43
Iraq	2,402	90,230	307	12,223	199

Sources : Ministry of Planning (1961) : Results of the Agricultural & Livestock Census in Iraq for the year 1958-59, Baghdad, Iraq, (in Arabic)

Appendix F, Table F.6 Number and Kind of Equipment Owned by Holders on 15.10.1971 by Province

Province	Tractors	Combine harvesters	Ploughs	Cultivators	Water Pumps	Transport Equipment	Other Implements
Nineveh	2,331	1,076	2,806	882	2,021	1,433	938
Arbil	460	106	1,469	254	397	612	1,110
Sulaimaniya	600	144	400	121	61	113	62
Kirkuk	1,158	657	502	1,096	1,049	1,581	545
Northern Region	4,549	1,983	5,177	2,353	3,528	3,739	2,655
Diala	725	43	687	611	371	266	699
Baghdad	846	77	983	663	3,626	710	2,391
Anber	483	6	401	317	2,117	221	137
Kerbela	45	0	51	18	424	159	352
Babil	310	3	528	248	423	189	1,362
Central Region	2,409	129	2,650	1,857	6,961	1,545	4,941
Al-Qadisiya	250	89	201	135	999	50	1,097
Wasit	407	82	578	170	972	177	468
Thi-Qar	334	20	373	62	311	69	2,238
Maysan	640	21	907	394	1,079	101	184
Basrah	136	3	51	15	2,600	188	2,292
Southern Region	1,767	215	2,110	776	5,961	585	6,279
Iraq	8,725	2,327	9,937	4,986	16,450	5,869	13,875

Source : Ministry of Planning (1973) : Results of 1971 Census of Agriculture, Baghdad, Iraq, Part one, Table 43P, pp.158-159.

Appendix F, Table F.7 — Number of Tractors Available at the Ministry of Agrarian Reform by Province

Province	1960	1961	1962	1963	1964	1965		1966 **		1967		1968		1969		1970	1971	1972	1973	1974	1975
						No.	hp.	No.	hp.	No.	hp.	No.	hp.	No.	hp.						
Nineveh	-	20	22	27	28	27	1,430			30	1,610	28	1,501	24	1,295	19	47	45	43	47	269
Arbil	19	39	31	37	37	34	1,790			38	1,940	38	1,940	38	1,940	28	23	22	35	35	88
Sulaimaniya	16	31	31	27	30	-	-			15	790	28	1,492	28	1,492	22	41	40	60	54	129
Kirkuk	16	31	40	38	32	59	2,977			55	2,770	39	1,906	39	1,906	26	24	48	57	60	174
Northern Region	51	121	124	129	127	120	6,197			138	7,110	133	6,839	129	6,633	95	135	155	195	196	660
Diala	-	24	29	27	23	23	1,171			29	1,471	32	1,656	34	1,766	27	31	32	45	53	224
Baghdad	65*	81	66	83	67	122	6,095			186	9,561	168	8,874	122	6,018	156	134	76	90	115	211
Anbar	-	7	12	12	10	23	1,262			33	1,860	33	1,860	38	1,790	23	41	15	16	26	101
Kerbela	-	8	12	13	6	6	297			20	1,060	9	489	20	1,091	15	24	15	20	21	51
Babil	9	8	8	13	18	14	703			22	1,160	21	1,124	20	1,024	18	31	18	23	28	52
Central Region	74	128	127	148	124	188	9,528			290	15,112	263	14,003	234	11,689	239	261	156	194	243	639
Al-Qadisiya	30	39	36	35	31	37	2,035			40	2,190	24	1,326	33	1,772	24	56	28	53	58	157
Wasit	49	71	102	112	95	98	5,365			106	5,831	137	7,499	120	6,253	110	83	79	88	104	314
Thi-Qar	7	7	7	12	14	24	1,183			26	1,293	23	1,178	23	1,178	87	37	30	23	27	75
Maysan	19	19	25	23	28	22	1,220			31	1,715	32	1,787	32	1,787	55	30	30	27	26	88
Basrah	-	2	6	8	5	10	475			6	328	4	228	4	228	28	17	8	8	14	100
Southern Region	105	138	176	190	173	191	10,278			209	11,357	220	12,018	212	11,218	304	223	175	199	229	734
Iraq	230	387	427	467	424	499	26,003			637	33,579	616	32,860	575	29,540	638	619	486	588	668	2,033

* including Baghdad, Diala and Anbar Provinces.
** No data available.
Sources : Ministry of Planning : Annual Abstracts of Statistics, 1960-1975, Baghdad, Iraq.

Appendix F, Table F.8 Number of Combines Available at the Ministry of Agrarian Reform by Province

Province	1961	1962	1963	1964	1965		1966*		1967		1968		1969		1970	1971	1972	1973	1974	1975
					No.	hp.	No.	hp.	No.	hp	No.	hp.	No.	hp.						
Nineveh	-	19	32	28	37	2,550			30	2,100	26	1,820	29	2,175	49	41	70	95	94	122
Arbil	12	15	17	19	27	1,735			30	1,990	35	2,415	35	2,475	25	25	40	56	56	96
Sulaimaniya	2	4	4	4	-	-			-	-	36	2,630	32	2,400	25	36	42	50	50	105
Kirkuk	12	20	17	12	28	1,868			30	2,700	40	3,450	45	3,375	45	55	55	85	85	155
Northern Region	26	58	70	63	92	6,153			90	6,790	137	10,315	141	10,425	144	157	207	286	285	478
Diala	-	7	9	9	13	900			20	1,300	30	2,050	30	2,250	46	50	33	43	43	118
Baghdad	21	30	54	33	78	5,490			106	7,181	197	14,092	169	11,695	191	213	97	132	132	250
Anbar	-	3	3	-	8	610			6	480	6	480	6	480	9	13	3	3	3	46
Kerbela	-	-	-	-	-	-			-	-	-	-	-	-	5	5	10	15	15	-
Babil	-	-	2	2	12	850			11	775	11	710	11	715	21	26	24	18	18	37
Central Region	21	40	68	44	111	7,850			143	9,736	244	17,332	216	15,140	272	307	167	211	211	451
Al-Qadisiya	30	17	30	19	32	2,163			43	3,985	57	4,025	57	4,225	70	70	55	67	67	74
Wasit	25	22	46	31	52	3,524			53	3,614	81	5,815	81	5,815	86	86	77	113	113	216
Thi-Qar	-	-	2	-	2	130			6	390	9	615	9	615	9	52	48	55	55	74
Maysan	1	-	3	3	8	570			10	720	17	1,235	13	840	18	18	26	34	34	41
Basrah	-	-	-	-	-	-			-	-	-	-	-	-	-	5	-	-	-	-
Southern Region	56	39	81	53	94	6,387			112	8,709	164	11,690	160	11,495	183	231	206	269	269	405
Iraq	103	137	219	160	297	20,390			345	25,235	545	39,337	517	37,060	599	695	580	766	765	1,334

* No data available

Source : Ministry of Planning : Annual Abstracts of Statistics, 1961 - 1975, Baghdad, Iraq.

Appendix F. Table F.9 No. of Ploughs Available at the Ministry of Agrarian Reform

Province	1971	1972	1973	1974	1975
Nineveh	32	32	30	32	120
Arbil	24	8	18	16	79
Sulaimaniya	34	41	56	56	84
Kirkuk	16	30	40	48	65
Northern Region	106	111	144	152	348
Diala	31	25	30	51	176
Baghdad	100	70	85	100	189
Anbar	29	17	16	15	82
Kerbela	25	15	20	21	51
Babil	29	16	21	23	47
Central Region	214	143	172	210	545
Al-Qadisiya	49	35	53	50	153
Wasit	105	67	78	91	272
Thi-Qar	30	32	27	24	55
Maysan	23	18	24	32	89
Basrah	17	7	8	14	43
Southern Region	224	159	190	211	612
Iraq	544	413	506	573	1,505

Sources : Ministry of Planning: Annual Abstract of Statistics, 1971-1975, Baghdad, Iraq.

Appendix F, Table F.10 No. of Agricultural Implements Available at the Ministry of Agrarian Reform

Province	1962	1963	1964	1971	1972	1973	1974	1975
Nineveh	44	50	50	47	46	47	56	227
Arbil	66	80	80	22	18	18	39	76
Sulaimaniya	40	2	2	5	3	5	10	58
Kirkuk	98	103	103	28	25	29	55	126
Northern Region	248	235	235	102	92	99	160	487
Diala	41	40	40	24	16	19	37	115
Baghdad	43	38	38	208	59	59	55	95
Anbar	14	18	18	20	20	20	25	57
Kerbela	13	13	13	2	5	8	11	18
Babil	8	8	8	5	4	9	14	23
Central Region	119	117	117	259	104	115	142	308
Al-Qadisiya	42	11	11	21	10	25	13	54
Wasit	107	125	125	79	59	70	86	306
Thi-Qar	6	6	6	7	4	8	16	30
Maysan	18	2	2	2	9	14	22	45
Basrah	5	5	5	15	9	6	14	19
Southern Region	178	149	149	124	91	123	151	454
Iraq	545	501	501	485	287	337	453	1,249

Source : Ministry of Planning: Annual Abstract of Statistics, 1962-1975, Baghdad, Iraq.

Appendix F, Table F.11 Number of Tractors, Combines and Agricultural Implements Owned by Agricultural Cooperatives by Province

Province	1974			1975			1976		
	Tractors	Combines	Agricultural Implements	Tractors	Combines	Agricultural Implements	Tractors	Combines	Agricultural Implements
Nineveh	106	64	228	207	126	295	230	125	469
Arbil	20	-	43	88	-	114	114	-	260
Sulaimaniya	-	-	-	29	-	-	89	3	160
Kirkuk	63	20	112	81	23	73	44	14	92
Northern Region	189	84	383	405	149	482	477	142	981
Diala	27	-	156	31	-	68	27	-	77
Baghdad	7	-	24	25	-	9	-	-	-
Anbar	9	-	28	27	-	31	30	-	61
Kerbela	2	-	6	20	-	19	16	-	46
Babil	34	-	114	44	-	108	40	-	97
Salah Al-Deen*	-	-	-	-	-	-	29	4	69
Najaf*	-	-	-	-	-	-	33	-	65
Central Region	79	-	328	147	-	235	175	4	415
Al-Qadisiya	15	-	57	20	-	56	17	-	62
Wasit	37	-	112	185	-	277	183	-	256
Thi-Qar	26	-	56	10	-	25	2	-	5
Maysan	32	-	58	35	-	50	31	-	36
Basrah	9	-	35	9	-	20	9	-	9
Southern Region	119	-	318	259	-	428	242	-	368
Iraq	387	84	1,029	811	149	1,145	894	146	1,764

* These two provinces were created in 1976 Source: Min.of Planning: Ann.Abst.of Statistics,1974-76,Baghdad,Iraq.

Appendix G, Table G.1

Methods of Irrigation by Province According to the 1958/59 Agricultural Census

(DONUMS)

Province	Rainfed	Gravity Irrigation	Pump Irrigation	Other methods of irrigation	Total
Nineveh	6,875,226	91,369	41,370	7,450	7,015,415
Arbil	2,301,303	89,665	2,310	625	2,393,903
Sulaiman-iya	959,385	420,616	283	968	1,381,252
Kirkuk	2,969,298	516,819	1,503	205	3,487,825
Northern Region	13,105,212	1,118,469	45,466	9,248	14,278,395
Diala	1,262,706	1,553,990	92,902	27,321	2,936,919
Baghdad	505,433	426,115	1,281,116	2,849	2,215,513
Anbar	38,521	105,674	279,405	32,858	456,458
Kerbela	29,498	135,433	10,363	8,753	184,047
Babil	6,485	1,270,163	68,366	51,686	1,396,700
Central Region	1,842,643	3,491,375	1,732,152	123,467	7,189,637
Al-Qadis-iya	12,025	859,714	1,292,118	49,953	2,213,810
Wasit	49,579	680,069	1,680,097	2,527	2,412,272
Thi-Qar	39,381	1,648,601	342,478	45,033	2,075,493
Maysan	391,621	623,761	628,882	5,223	1,649,487
Basrah	4,859	240,051	74,174	7,431	326,515
Southern Region	497,465	4,052,196	4,017,749	110,167	8,677,577
Iraq	15,445,320	8,662,040	5,795,367	242,882	30,145,609

Source : Ministry of Planning (1961) : Results of The Agricultural and Livestock Census in Iraq for the Year 1958/59, Baghdad, Iraq (in Arabic).

Appendix G, Table G.2

The Distribution of Installed Water Pumps by Province

Province	1949/50		1950/51		1951/52		1952/53		1953/54		1954/55		1955/56		1956/57		1957/58	
	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.
Nineveh	74	2,393	93	3,296	101	3,100	103	3,188	124	3,687	134	3,946	137	4,067	156	4,543	162	4669
Arbil	2	68	1	9	4	141	4	141	5	179	5	179	5	179	5	179	5	179
Sulaiman-iya	-	-	-	-	-	-	-	-	-	-	1	22	2	32	2	32	2	32
Kirkuk	3	44	11	237	13	294	13	294	15	343	18	423	22	566	24	656	28	753
Northern Region	79	2,505	105	3,542	118	3,535	120	3,623	144	4,209	158	4,570	166	4,844	187	5,410	197	5,633
Diala	122	5,795	135	6,436	131	5,845	137	6,212	163	7,420	178	7,875	181	8,094	195	8,539	198	8,652
Baghdad	1,315	41,780	1,309	44,148	1,289	45,653	1,328	46,597	1,401	48,965	1,441	50,175	1,502	51,907	1,547	53,238	1,578	54,331
Anbar	265	7,904	296	8,745	330	9,634	352	10,250	392	11,315	403	11,660	435	12,460	456	12,930	488	13,644
Kerbela	30	651	30	665	30	633	30	633	32	600	34	618	35	623	40	681	42	751
Babil	86	2,032	103	2,495	131	3373	153	3841	143	4479	156	4,610	168	4,966	183	5,157	195	5,423
Central Region	1,818	58,162	1,873	62,489	1,911	65,138	2,000	67,533	2,131	72,779	2,212	74,944	2,321	78,050	2,421	80,545	2,501	82,801
Al-Qadis-iya	570	22,610	581	23,528	696	27,790	799	31,683	800	31,913	871	34,338	904	35,669	939	37,012	984	38,467
Wasit	548	26,076	616	29,757	651	34,178	689	36,438	736	37,358	781	39,294	840	42,184	880	44,055	912	45,660
Thi - Qar	106	4,674	114	5,101	143	6,002	155	7,471	156	7,220	175	8,209	200	9,280	239	10,960	245	11,176
Maysan	354	13,656	374	14,479	426	15,760	448	16,805	448	17,892	455	18,167	459	18,310	462	18,336	468	18,540
Basrah	118	3,455	112	3,211	123	3,571	128	3,726	132	3,809	132	3,809	135	3,926	136	3,961	137	3,983
Southern Region	1,696	70,471	1,797	76,076	2,039	87,301	2,219	96,123	2,272	98,192	2,414	103,817	2,538	109,369	2,656	114,324	2,746	117,826
Iraq	3,593	131,138	3,775	142,107	4,068	155,974	4,339	167,279	4,547	175,180	4,784	183,331	5,025	192,263	5,264	200,279	5,444	206,260

Sources : 1. Ministry of Economics, Annual Abstracts of Statistics, 1950-198. 2. Ministry of Planning, Annual Abstracts of Statistics, 1959-75.

Table G.2 (Cont.)

Province	1958/59		1959/60		1960/61		1961/62		1962/63		1963/64		1964/65		1965/66		1966/67	
	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.
Nineveh	196	6,401	204	6,537	264	6,947	394	7,856	442	8137	923	11,883	975	12,298			1,267	15,119
Arbil	9	185	9	185	26	188	28	187	28	187	128	904	129	910			129	910
Sulaiman-iya	2	32	2	32	2	32	31	538	33	559	33	559	33	559			33	559
Kirkuk	44	1,183	46	1,253	42	1,041	69	945	84	1,071	167	1,797	213	2,193			271	2,545
Northern Region	251	7,801	261	8,007	334	8,208	522	9,526	587	9,954	1,251	15,143	1,350	15,960			1,700	19,233
Diala	185	7,959	189	8,046	185	7,980	218	8,344	221	8477	262	9,319	289	10,127			417	12,284
Baghdad	1,493	52,424	1,527	53,198	1,575	57,169	1,619	57,689	1,651	58,490	2,073	67,562	2,227	74,003			2,323	76,834
Anbar	517	13,711	558	14,688	564	14,915	583	15,162	603	15,639	664	17,105	681	18,305			807	21,048
Kerbela	63	1,154	71	1,304	244	2,314	149	2,123	175	2,802	229	4,097	248	4,189			412	10,213
Babil	185	4,299	197	4,463	261	5,186	314	5,931	349	6,486	375	7,004	394	7,506			462	8,456
Central Region	2,443	79,547	2,542	81,699	2,829	87,564	2,883	89,249	2,999	91,894	3,603	105,087	3,839	114,130			4,421	128,835
Al-Qadis-iya	1,130	43,821	1,145	44,191	1,130	43,097	1,226	45,506	1,426	46,306	1,409	50,383	1,425	50,771			1,479	52,616
Wasit	899	45,544	913	46,201	1,002	50,107	1,067	53,254	1,082	53,852	1,105	54,403	1,126	54,934			1,260	59,785
Thi-Qar	235	10,275	240	10,427	220	9,903	216	9,148	234	9,798	258	10,331	280	10,558			321	11,797
Maysan	511	21,129	514	21,235	521	20,694	532	20,950	640	21,865	658	22,281	760	27,375			807	28,362
Basrah	179	5,074	181	5,150	193	5,290	209	5,511	214	5,563	228	6,015	229	6,024			233	6,124
Southern Region	2,954	123,843	2,993	127,204	3,066	129,091	3,250	134,379	3,596	137,384	3,658	143,413	3,820	149,662			4,100	158,684
Iraq	5,648	213,191	5,796	216,910	6,229	224,863	6,655	233,154	7,182	239,232	8,512	263,643	9,009	279,752	9,740	296,021	10,221	306,752

Table G.2 (Cont.)

Province	1967/68		1968/69		1969/70		1970/71		1971/72		1972/73		1973/74		1974/75	
	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.	No.	H.P.
Nineveh	1,481	17,088	1,763	19,111	1,947	20,302	2,305	23,377	2,357	23,748	1,916	16,790	3,445	27,194	3,469	27,106
Arbil	235	1,424	326	1,715	367	1,959	304	2,076	786	5,646	723	5,022	723	5,022	848	5,841
Sulaimaniya	33	559	33	559	33	559	52	1,044	36	560	85	1,335	85	1,335	54	1,024
Kirkuk	471	4,617	557	5,617	707	6,761	775	7,314	1,112	10,622	1,096	10,246	1,005	9,628	1,396	14,238
Northern Region	2,220	23,588	2,679	27,002	3,054	29,581	3,436	33,811	4,291	40,576	3,820	33,393	5,258	43,179	5,767	48,209
Diala	513	13,877	661	16,688	697	17,539	566	14,845	531	14,190	564	14,824	349	7,348	351	7,137
Baghdad	2,443	79,923	2,698	83,401	2,302	91,210	2,807	88,231	3,087	86,949	3,537	94,514	3,888	97,543	4,384	111,122
Anbar	878	22,216	922	22,985	965	23,789	1,302	27,237	1,346	26,030	1,347	26,039	1,488	27,714	1,549	29,190
Kerbela	557	12,991	646	14,543	727	15,596	702	15,145	786	16,700	770	16,405	837	16,393	975	21,024
Babil	526	9,403	611	11,057	637	11,318	641	11,394	531	9,196	225	3,340	570	8,732	596	9,018
Central Region	4,917	162,098	5,538	153,674	5,828	159,452	6,018	156,852	6,281	153,065	6,443	155,122	7,132	157,730	7,855	177,491
Al-Qadisiya	1,575	55,415	1,843	62,919	1,839	62,594	1,507	39,986	1,683	56,395	1,692	56,439	1,843	59,032	1,953	60,294
Wasit	1,324	61,916	1,362	63,219	1,386	64,297	1,458	64,340	1,477	64,439	1,501	64,926	1,520	64,598	1,565	67,077
Thi-Qar	363	13,570	389	14,264	405	14,476	413	14,527	457	13,223	484	11,277	559	11,378	867	14,226
Maysan	978	29,451	985	29,536	995	29,695	1,046	34,292	1,040	34,286	1,068	33,284	1,085	33,875	1,166	37,014
Basrah	238	6,230	250	6,485	262	6,656	257	6,527	255	6,901	723	10,017	707	9,548	786	9,881
Southern Region	4,478	166,582	4,829	176,423	4,887	177,718	4,681	159,672	4,912	175,244	5,468	175,943	5,714	178,431	6,337	188,492
Iraq	11,615	352,368	13,046	357,099	13,769	366,751	14,135	350,335	15,484	368,885	15,731	364,458	18,104	379,340	19,959	414,192

Appendix H, Table H.1 Area Under Wheat Production (Thousand Donums)

Province	1949/50	1950/51	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63
Nineveh	970	967	1,048	1,634	2,126	2,340	2,012	2,539	2,727	2,736	1,618	1,731	2,333	2,560
Arbil	222	391	637	637	640	610	531	596	683	599	612	770	767	829
Sulaimaniya	112	65	62	64	206	138	124	174	97	83	101	121	133	108
Kirkuk	428	948	722	812	934	839	828	784	821	776	791	804	873	968
Northern Region	1,732	2,371	2,469	3,147	3,906	3,927	3,495	4,093	4,328	4,194	3,122	3,426	4,106	4,465
Diala	258	238	306	314	317	345	363	372	425	389	425	417	429	464
Baghdad	382	339	350	388	430	394	386	378	398	403	450	469	556	571
Anbar	77	72	77	91	92	99	102	120	99	98	110	140	159	174
Kerbela	15	8	8	7	6	13	15	9	9	10	10	12	11	12
Babil	57	28	55	93	93	97	95	48	50	47	55	73	88	93
Central Region	789	685	796	893	938	948	961	927	981	947	1,050	1,111	1,243	1,314
Al-Qadisiya	299	186	157	156	162	157	173	153	159	169	200	199	268	254
Wasit	759	357	327	389	366	450	419	432	413	360	397	336	406	439
Maysan	54	56	70	92	113	122	94	76	92	89	100	100	112	124
Thi-Qar	159	52	52	46	71	90	99	131	141	181	198	202	217	214
Basrah	8	3	3	4	3	6	15	13	19	20	18	11	11	8
Southern Region	1,279	654	609	687	715	825	800	805	824	819	913	848	1,014	1,039
Iraq	3,800	3,710	3,874	4,727	5,559	5,700	5,256	5,825	6,133	5,960	5,085	5,385	6,363	6,818

Province	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
Nineveh	2,937	2,950	2,980	3,375	3,528	3,709	3,402	3,533	3,654	998	3,443	2,686	3,620
Arbil	693	753	830	825	847	845	820	990	1,169	808	964	746	964
Sulaimaniya	66	104	65	142	194	217	306	700	818	583	586	300	546
Kirkuk	669	689	703	704	814	953	1,117	1,100	1,483	726	1,388	752	998
Northern Region	4,365	4,496	4,578	5,046	5,383	5,724	5,645	6,323	7,124	3,115	6,381	4,484	6,128
Diala	212	431	365	375	385	418	377	460	298	245	397	279	514
Baghdad	616	517	624	634	735	723	650	812	713	450	493	421	494
Anbar	132	148	145	143	161	129	148	250	207	133	198	98	117
Kerbela	12	14	13	13	14	15	17	22	22	21	16	24	25
Babil	143	137	145	135	151	147	123	309	214	205	225	125	234
Central Region	1,115	1,247	1,292	1,300	1,446	1,432	1,315	1,853	1,454	1,054	1,329	947	1,384
Al-Qadisiya	264	253	265	268	291	292	245	598	516	479	346	190	296
Wasit	382	421	420	415	547	573	568	879	838	583	493	536	500
Maysan	129	138	127	121	148	155	145	220	131	125	121	144	131
Thi-Qar	242	246	250	206	210	178	212	394	364	271	309	277	289
Basrah	10	12	15	11	15	6	5	33	30	28	18	16	16
Southern Region	1,027	1,070	1,077	1,021	1,211	1,204	1,175	2,124	1,879	1,486	1,287	1,163	1,232
Iraq	6,507	6,813	6,947	7,367	8,040	8,360	8,135	10,300	10,457	5,655	8,997	6,594	8,744

Source: 1.1949/50 - 58/59 : Ministry of Economics, Annual Abstract of Statistics, 1950-1958.
2.1959/60 - 1968/69 : Ministry of Planning, Annual Abstract of Statistics, 1959-1969.
3.1969/70 - 1975/76 : Directly from the Ministry of Agriculture and Agrarian Reform.

Appendix H, Table H.2

Production of Wheat by Province (Thousand Tons)

Province	1949/50	1950/51	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63
Nineveh	100	52	141	222	478	74	304	459	261	193	173	268	446	196
Arbil	19	63	68	104	128	23	70	103	73	66	44	88	123	26
Sulaimaniya	18	10	9	7	69	29	18	26	12	11	16	22	23	2
Kirkuk	50	90	54	109	215	67	93	185	67	74	69	145	118	48
Northern Region	187	215	272	442	890	193	485	773	413	344	302	523	710	272
Diala	31	32	15	42	42	41	50	74	42	38	43	76	52	31
Baghdad	49	67	65	68	56	54	71	95	104	55	77	79	95	29
Anbar	13	19	17	31	26	17	16	18	22	13	16	24	25	30
Kerbela	2	2	2	2	2	2	2	2	2	1	1	2	1	2
Babil	19	5	15	23	19	15	14	11	11	6	9	13	17	14
Central Region	114	125	114	166	145	129	153	200	181	113	146	194	190	106
Al-Qadisiya	62	54	43	40	42	29	31	24	38	23	32	36	52	34
Wasit	114	77	33	80	40	68	75	86	71	46	62	50	73	54
Maysan	8	8	10	19	26	19	15	15	16	12	18	18	20	17
Thi-Qar	34	8	8	12	17	15	14	18	35	21	30	35	39	31
Basrah	1	0.5	-	1	-	-	3	2	3	2	2	1	1	1
Southern Region	219	147.5	94	152	125	131	138	145	163	104	144	140	185	137
Iraq	520	487.5	480	760	1,160	453	776	1,118	757	561	592	857	1,085	515

Province	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
Nineveh	357	415	250	219	566	579	363	360	1,125	109	532	271	739
Arbil	56	98	80	98	146	92	59	89	201	103	127	85	182
Sulaimaniya	7	15	10	22	37	30	49	112	214	112	135	60	125
Kirkuk	45	93	78	50	150	118	89	121	416	74	233	109	206
Northern Region	465	621	418	389	899	819	560	682	1,956	398	1,027	525	1,252
Diala	19	58	52	62	63	43	53	63	75.1	39	85	49	106
Baghdad	109	96	109	161	147	82	110	146	228.3	80	119	75	98
Anbar	19	24	24	16	20	19	34	48	46.4	25	47	20	37
Kerbela	2	2	2	3	3	3	4	3	6.5	4	4	5	7
Babil	26	24	25	36	28	22	32	59	69.5	55	62	32	81
Central Region	175	204	212	278	261	169	233	319	425.8	203	317	181	329
Al-Qadisiya	52	45	56	55	49	51	56	92	155	111	100	51	79
Wasit	57	70	71	75	102	94	128	167	214	107	136	117	207
Maysan	20	24	23	28	32	23	33	33	31	23	34	45	28
Thi-Qar	37	40	44	33	26	31	49	59	97	49	77	71	71
Basrah	1	2	2	2	2	1	1	4	6	4	5	5	2
Southern Region	167	181	196	193	211	200	267	355	503	294	352	289	387
Iraq	807	1,006	826	860	1,371	1,188	1,060	1,356	2,884.8	895	1,695	995	1,968

Source : As in Appendix H, Table H.1.

Appendix H, Table H.3 **Area under Barley Production (Thousand Donums)**

Province	1949/50	1950/51	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63
Nineveh	908	620	472	571	647	892	849	1,272	980	916	613	597	776	813
Arbil	159	208	239	219	322	340	350	205	163	152	169	214	210	225
Sulaimaniya	215	58	52	51	240	145	159	172	104	90	98	115	121	93
Kirkuk	330	532	427	458	516	537	522	491	497	452	423	421	429	398
Northern Region	1,612	1,418	1,190	1,299	1,725	1,914	1,880	2,140	1,744	1,610	1,303	1,347	1,536	1,529
Diala	451	403	452	536	492	530	540	583	535	505	483	531	520	516
Baghdad	335	328	346	328	368	328	336	333	332	316	325	342	404	427
Anbar	44	40	40	62	78	82	73	66	56	58	49	74	85	99
Kerbela	21	11	11	8	12	13	14	15	12	12	15	15	13	17
Babil	253	318	286	272	245	283	281	225	352	425	505	483	671	720
Central Region	1,104	1,100	1,135	1,206	1,195	1,236	1,244	1,222	1,287	1,316	1,377	1,445	1,693	1,779
Al-Qadisiya	164	209	172	714	177	206	220	175	164	163	173	181	290	266
Wasit	506	487	445	508	754	693	658	710	695	595	568	481	506	544
Maysan	272	195	238	283	341	363	267	206	225	215	248	234	236	257
Thi-Qar	340	260	348	374	296	406	390	503	509	454	481	475	496	498
Basrah	2	0.5	-	1	1	1	23	3	2	2	1	1	1	1
Southern Region	1,284	1,151.5	1,203	1,880	1,569	1,669	1,558	1,597	1,595	1,429	1,471	1,372	1,529	1,566
Iraq	4,000	3,669.5	3,528	4,385	4,489	4,819	4,682	4,959	4,626	4,355	4,151	4,164	4,758	4,874

Province	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
Nineveh	829	854	889	912	1,070	1,117	940	929	984	357	812	593	695
Arbil	129	194	355	362	375	373	336	423	357	229	412	226	273
Sulaimaniya	51	85	49	105	108	78	98	116	149	333	116	44	134
Kirkuk	289	278	294	205	370	416	406	436	579	262	516	332	294
Northern Region	1,298	1,411	1,587	1,584	1,923	1,984	1,780	1,904	2,069	1,181	1,856	1,195	1,396
Diala	362	489	458	452	435	453	385	430	269	219	281	219	290
Baghdad	421	280	367	376	374	348	360	293	200	136	117	100	239
Anbar	77	88	99	96	103	79	91	114	76	72	101	52	58
Kerbela	15	14	14	13	14	19	13	18	18	16	11	18	18
Babil	741	586	579	560	611	606	370	387	336	305	272	82	256
Central Region	1,616	1,457	1,517	1,497	1,537	1,505	1,219	1,242	899	748	782	471	861
Al-Qadisiya	279	283	300	304	321	321	266	279	271	240	203	68	149
Wasit	413	446	450	381	452	446	420	775	612	481	365	435	397
Maysan	249	250	254	181	218	204	160	226	136	116	96	99	107
Thi-Qar	534	535	566	391	415	411	411	392	363	332	303	377	316
Basrah	2	2	3	4	4	1	1	1	2	4	5	4	5
Southern Region	1,477	1,516	1,573	1,261	1,410	1,383	1,258	1,678	1,384	1,173	972	983	974
Iraq	4,391	4,384	4,677	4,342	4,870	4,872	4,257	4,819	4,352	3,102	3,610	2,649	3,231

Source : As in Appendix H, Table H.1.

Appendix H, Table H.4 **Production of Barley by Province (Thousand Tons)**

Province	1949/50	1950/51	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63
Nineveh	116	36	83	178	232	53	199	395	138	108	106	121	218	117
Arbil	28	42	45	61	81	21	79	54	23	25	22	33	40	18
Sulaimaniya	27	11	9	7	117	44	33	33	17	18	18	24	24	2
Kirkuk	49	58	40	156	250	81	113	145	62	81	44	91	86	48
Northern Region	220	147	177	402	680	199	424	627	240	232	190	269	368	185
Diala	75	78	36	128	87	84	93	120	93	70	81	110	92	60
Baghdad	58	76	76	68	75	56	84	98	100	76	82	87	103	68
Anbar	9	13	12	28	21	17	16	14	16	9	9	16	18	4
Kerbela	5	3	3	2	2	3	3	3	2	2	3	3	3	3
Babil	66	99	78	81	76	57	59	54	101	93	124	126	173	164
Central Region	213	269	205	307	261	217	255	289	312	250	299	342	389	299
Al-Qadisiya	82	84	65	66	65	44	49	50	52	27	35	38	78	42
Wasit	160	264	77	135	74	145	142	184	159	106	124	102	114	111
Maysan	45	32	52	78	96	72	56	59	59	35	56	54	58	49
Thi-Qar	80	43	76	123	63	80	85	94	131	82	100	106	118	104
Basrah	0.5	0.1	-	-	-	-	5	1	1	1	0	0	0	0
Southern Region	367.5	423.1	270	402	298	341	337	388	402	251	315	300	368	306
Iraq	800.5	839.1	652	1,111	1,239	757	1,016	1,304	954	733	804	911	1,125	790

Province	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
Nineveh	126	163	142	100	201	365	109.5	129	328	41.3	155.5	47.7	174.6
Arbil	18	32	58	52	77	16	30.0	45	71	30.8	71.7	29.7	66.3
Sulaimaniya	4	13	7	15	21	12	13.4	21	32	60.4	24.9	11.0	30.2
Kirkuk	24	46	43	24	71	137	47.9	58	168	24.7	109.4	49.9	77.7
Northern Region	172	254	250	191	370	530	200.8	253	599	157.2	361.5	138.3	348.8
Diala	39	77	63	121	79	104	49.9	62	47	26.7	52.8	38.5	53.2
Baghdad	69	52	70	117	90	111	78.7	62	58	22.2	28.1	22.0	43.5
Anbar	10	17	19	11	11	16	20	23	15	8.2	21.9	9.8	12.6
Kerbela	2	3	3	3	3	4	3	4	5	3	3.3	3.2	3.6
Babil	129	112	116	152	128	167	84	81	91	70.9	65.4	15.8	68.0
Central Region	249	261	271	404	311	402	235.6	232	216	131	171.5	89.3	180.9
Al-Qadisiya	41	55	60	59	51	53	46.2	57	79.2	52.5	64.3	11.5	34.4
Wasit	55	85	90	80	85	74	81.9	141	111.2	76.4	97.7	83.8	80.3
Maysan	32	50	53	43	53	55	36.0	39	25	18.3	24.8	24.2	22.4
Thi-Qar	74	99	108	77	61	77	90.7	67.	74.4	55.5	69.4	94.7	66.9
Basrah	-	-	-	1	1	-	0.17	0.24	0.43	0.6	0.8	1.0	0.7
Southern Region	202	289	311	260	251	259	254.97	304.24	290.23	203.3	257	215.2	204.7
Iraq	623	804	832	855	932	1,191	691.37	789.24	1,105.23	491.5	790.0	442.8	734.4

Source : As in Appendix H, Table H.1.

Appendix H, Table H.5 Wheat Yields (kg./donum)

Province	1949/50	1950/51	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63
Nineveh	103.1	53.8	134.5	135.9	224.8	31.6	151.1	180.8	95.7	70.5	106.9	154.8	191.2	76.6
Arbil	85.6	161.1	106.8	163.3	200.0	37.7	131.8	172.8	106.9	110.2	71.9	114.3	160.4	31.4
Sulaimaniya	160.7	153.9	145.2	109.4	335.0	210.2	145.2	149.4	123.7	132.5	158.4	181.8	172.9	18.5
Kirkuk	116.8	94.9	74.8	134.2	230.2	79.9	112.3	236.0	81.6	95.4	87.2	180.3	135.2	49.6
Northern Region	108.0	90.7	110.2	140.5	227.9	49.2	138.8	188.9	95.4	82.0	96.7	152.7	172.9	60.9
Diala	120.2	134.5	49.0	133.8	132.5	118.8	137.7	198.9	98.8	97.7	101.2	182.3	121.2	66.8
Baghdad	128.3	197.6	185.7	175.3	130.2	137.1	183.9	251.3	261.3	136.5	171.1	168.4	170.9	50.8
Anbar	168.8	263.9	220.8	340.7	282.6	171.7	156.9	150.0	222.2	132.7	145.5	171.4	157.2	172.4
Kerbela	133.3	250.0	250.0	285.7	333.3	153.9	133.3	222.2	222.2	100.0	100.0	166.7	90.9	166.7
Babil	333.3	178.6	272.7	247.3	204.3	154.6	147.4	229.2	220.0	127.7	163.6	178.1	193.2	150.5
Central Region	144.5	182.5	143.2	185.9	154.6	136.1	159.2	215.8	184.5	119.3	139.1	174.6	152.9	80.7
Al-Qadisiya	207.4	290.3	273.9	256.4	259.3	184.7	179.2	156.9	239.0	136.1	160.0	180.9	194.0	133.9
Wasit	150.2	215.7	100.9	205.7	109.3	151.1	179.0	199.1	171.9	127.8	156.2	148.8	179.8	123.0
Maysan	148.2	142.9	142.9	206.5	230.1	155.7	159.6	197.4	173.9	134.8	180.0	180.0	178.6	137.1
Thi-Qar	213.8	153.9	153.9	260.9	239.4	166.7	141.4	137.4	248.2	116.0	151.5	173.3	179.7	144.9
Basrah	125.0	166.7	-	250.0	-	-	200.0	153.9	157.9	100.0	111.1	90.9	90.9	125.0
Southern Region	171.2	225.5	154.4	221.3	174.8	158.8	172.5	180.1	197.8	127.0	157.7	165.1	182.5	131.9
Iraq	136.8	131.4	123.9	160.8	208.7	79.5	147.6	191.9	123.4	94.1	116.4	159.2	170.5	75.5

Province	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
Nineveh	121.6	140.7	83.9	64.9	160.4	156.1	106.7	101.9	308.0	109.2	154.5	100.9	204.1
Arbil	80.8	130.2	96.4	118.8	172.4	108.9	72.0	90.0	171.9	127.5	131.7	113.9	188.8
Sulaimaniya	106.1	144.2	153.9	154.9	190.7	138.3	160.1	160.0	261.6	192.1	230.4	200.0	228.9
Kirkuk	67.3	135.0	111.0	71.0	184.3	123.8	79.7	110.0	280.5	101.9	167.9	145.0	206.4
Northern Region	106.5	138.1	91.3	77.1	167.0	143.1	99.2	107.9	274.6	127.8	160.9	117.1	204.3
Diala	89.6	134.6	142.5	165.3	163.6	102.9	140.6	137.0	252.0	159.2	214.1	175.6	206.2
Baghdad	176.9	185.7	174.7	253.9	200.0	113.4	169.2	180.0	320.2	177.8	241.4	178.2	198.4
Anbar	143.9	162.2	165.5	111.9	124.2	147.3	229.7	192.0	224.2	188.0	237.4	204.1	316.2
Kerbela	166.7	142.9	153.9	230.8	214.3	200.0	235.3	136.4	295.5	190.5	250.0	208.3	280.0
Babil	181.8	175.2	172.4	266.7	185.4	149.7	260.2	190.9	324.8	268.3	275.6	256.0	346.2
Central Region	157.0	163.6	164.1	213.9	180.5	118.0	177.2	172.2	292.8	192.6	238.5	191.1	237.7
Al-Qadisiya	197.0	177.9	211.3	205.2	168.4	174.7	228.6	153.8	300.4	231.7	289.0	268.4	266.9
Wasit	149.2	166.3	169.1	180.7	186.5	164.1	225.4	190.0	255.4	183.5	275.9	218.3	414.0
Maysan	155.0	173.9	181.1	231.4	216.2	148.4	227.6	150.0	237.0	184.0	281.0	312.5	213.7
Thi-Qar	152.9	162.6	176.0	160.2	123.8	174.2	231.1	150.0	266.5	180.8	249.2	256.3	245.7
Basrah	100.0	166.7	133.3	181.8	133.3	166.7	200.0	121.2	200.0	142.9	277.8	312.5	125.0
Southern Region	162.6	169.2	182.0	189.0	174.2	166.1	227.2	167.2	267.7	197.8	273.5	248.5	314.1
Iraq	124.0	147.7	118.9	116.7	170.5	142.1	130.3	131.7	275.9	158.3	188.4	150.9	225.1

Source : Calculated from Appendix H, Tables H.1 and H.2.

Appendix H, Table H.6

Barley Yields (Kg/donum)

Province	1949/50	1950/51	1951/52	1952/53	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63
Nineveh	127.8	58.1	175.9	311.7	358.6	59.4	234.4	310.5	140.8	117.9	172.9	202.7	280.9	143.9
Arbil	176.1	201.9	188.3	278.5	251.6	61.8	225.7	263.4	141.1	164.5	130.2	154.2	190.5	80.0
Sulaimaniya	125.6	189.7	173.1	137.3	487.5	303.5	207.6	191.9	163.5	200.0	183.7	208.7	198.4	21.5
Kirkuk	148.5	109.0	93.7	340.6	484.5	150.8	216.5	295.3	124.8	179.2	104.0	216.2	200.5	120.6
Northern Region	136.5	103.7	148.7	309.5	394.2	104.0	225.5	293.0	137.6	144.1	145.8	199.7	239.6	121.0
Diala	166.3	193.6	79.7	238.8	176.8	158.5	172.2	205.8	173.8	138.6	167.7	207.2	176.9	116.3
Baghdad	173.1	231.7	219.7	207.3	203.8	170.7	250.0	294.3	301.2	240.5	252.3	254.4	255.0	159.3
Anbar	204.6	325.0	300.0	451.6	269.2	207.3	219.2	212.1	285.7	155.2	183.7	216.2	211.8	40.4
Kerbela	238.1	272.7	272.7	250.0	166.7	230.8	214.3	200.0	166.7	166.7	200.0	200.0	230.8	176.5
Babil	260.9	311.3	272.7	297.8	310.2	201.4	210.0	240.0	286.9	218.8	245.6	260.9	257.8	227.8
Central Region	192.9	244.5	180.6	254.6	218.4	175.6	205.0	236.5	242.4	190.0	217.1	236.7	229.8	168.1
Al-Qadisiya	500.0	401.9	377.9	92.4	367.2	213.6	222.7	285.7	317.1	165.6	202.3	210.0	269.0	157.9
Wasit	316.2	542.1	173.0	265.8	98.1	209.2	215.8	259.2	228.8	178.2	218.3	212.1	225.3	204.0
Maysan	165.4	164.1	218.5	275.6	281.5	198.4	209.7	286.4	262.2	162.8	225.8	230.8	245.8	190.7
Thi-Qar	235.3	165.4	218.4	328.9	212.8	197.0	218.0	186.9	257.4	180.6	207.9	223.2	237.9	208.8
Basrah	250.0	200.0	-	-	-	-	217.4	333.3	500.0	500.0	-	-	-	-
Southern Region	286.2	367.4	224.4	213.8	189.9	204.3	216.3	243.0	252.0	175.7	214.1	218.7	240.7	195.4
Iraq	200.1	228.7	184.8	253.4	276.0	157.1	217.0	263.0	206.2	168.3	193.7	218.8	236.4	162.1

Province	1963/64	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
Nineveh	152.0	190.9	159.7	109.7	187.9	326.8	116.5	138.9	333.4	115.7	191.5	80.4	251.2
Arbil	139.5	165.0	163.4	143.7	205.3	42.9	89.3	106.4	198.9	134.5	174.0	131.4	242.9
Sulaimaniya	78.4	152.9	142.9	142.9	194.4	153.9	136.7	181.0	214.8	181.4	215.0	250.0	225.4
Kirkuk	83.1	165.5	146.3	117.1	191.1	329.3	118.0	133.0	290.2	94.3	212.0	150.3	264.3
Northern Region	132.5	180.0	157.5	120.6	192.4	267.1	112.8	132.8	289.5	133.1	194.8	115.7	249.9
Diala	107.7	157.5	137.6	267.7	181.6	229.6	129.6	144.2	174.7	121.9	187.9	175.8	183.4
Baghdad	163.9	185.7	190.7	311.2	240.6	319.0	218.6	212.0	290.0	163.2	240.2	220.0	182.0
Anbar	129.9	193.2	191.9	114.6	106.8	202.5	219.8	201.8	197.4	113.9	216.8	188.5	217.2
Kerbela	133.3	214.3	214.3	230.8	214.3	210.5	230.8	222.2	277.8	187.5	300.0	177.8	200.0
Babil	174.1	191.1	200.4	271.4	209.5	275.6	227.0	209.3	270.8	232.5	240.4	192.7	265.6
Central Region	154.1	179.1	178.6	269.9	202.3	267.1	193.3	186.8	240.3	175.1	219.3	189.6	210.1
Al-Qadisiya	147.0	194.4	200.0	194.1	158.9	165.1	173.7	204.3	292.3	218.8	316.8	169.1	230.9
Wasit	133.2	190.6	200.0	210.0	188.1	165.9	195.0	182.0	181.7	158.8	267.7	192.6	202.3
Maysan	128.5	200.0	208.7	237.6	243.1	269.6	225.0	173.0	182.0	157.8	258.3	244.4	209.3
Thi-Qar	138.6	185.1	190.8	196.9	147.0	187.4	220.7	170.9	205.0	167.2	229.0	251.2	211.7
Basrah	-	-	-	250.0	250.0	-	217.0	240.0	215.0	150.0	160.0	250.0	140.0
Southern Region	136.8	190.7	197.7	206.2	178.0	187.3	202.7	181.9	209.7	173.3	264.4	218.9	210.2
Iraq	141.9	183.4	177.9	196.9	191.4	244.5	162.4	163.8	254.0	158.5	218.8	167.2	227.3

Source : Calculated from Appendix H, Tables H.3 and H.4.

Appendix H, Table H.7 Monthly Minimum, Maximum, Mean, Standard Deviation and the Coefficient of Variation of Rainfall in the Northern Region

	No.of cases	Minimum	Maximum	Mean	St.Dev.	% Coefficient of Variation
Sinjar						
October	27	0.00	53.50	8.47	13.95	164.81
November	27	1.40	94.10	29.40	25.56	86.95
December	27	13.60	194.40	67.96	46.36	68.21
January	27	13.20	234.90	73.82	51.62	69.93
February	27	4.90	208.80	63.89	45.08	70.56
March	27	8.80	184.90	68.07	50.25	73.82
April	27	2.00	174.50	60.59	46.60	76.92
May	27	0.00	185.40	36.17	48.16	124.83
Mosul						
October	27	0.00	53.10	9.73	13.37	137.37
November	27	0.50	109.00	32.97	26.96	81.76
December	27	10.50	127.70	60.29	31.64	52.47
January	27	0.60	131.40	62.79	33.07	52.67
February	27	5.00	182.30	64.24	39.37	61.29
March	27	12.20	172.70	72.10	43.43	60.23
April	27	2.50	128.70	56.68	37.02	65.31
May	27	0.40	142.80	25.86	32.89	127.15
Talafar						
October	27	0.00	44.50	5.44	10.87	199.98
November	27	0.00	124.50	30.65	26.88	87.68
December	27	10.10	162.50	51.49	34.88	67.74
January	27	4.50	144.90	55.55	38.52	69.35
February	27	4.00	176.50	50.85	38.72	76.14
March	27	9.30	146.00	58.29	39.41	67.61
April	27	1.80	154.50	49.50	38.99	78.76
May	27	0.00	145.40	22.30	30.80	138.12
Aqra						
October	20	0.00	82.00	24.13	22.85	94.70
November	20	19.90	192.90	93.99	45.34	48.24
December	20	47.20	472.40	145.63	95.83	65.81
January	20	14.10	241.30	146.30	77.54	53.00
February	20	34.70	429.30	155.73	96.07	61.69
March	20	21.10	326.00	148.30	79.60	53.68
April	20	41.20	268.80	126.84	61.80	48.72
May	20	0.00	227.70	41.38	53.20	128.55

Appendix H, Table H. 7 (Cont.)

	No.of cases	Minimum	Maximum	Mean	St. Dev.	% Coefficient of Variation
Sersank						
October	20	0.00	125.90	19.22	32.39	168.54
November	20	2.10	324.00	107.30	107.84	100.50
December	20	9.20	336.20	145.59	97.27	66.81
January	20	15.60	349.90	134.81	86.87	64.44
February	20	19.30	395.50	161.02	129.99	80.73
March	20	25.50	357.70	170.33	112.08	65.80
April	20	22.00	472.50	151.45	114.22	75.42
May	20	1.30	261.50	61.93	68.19	110.11
Duhok						
October	20	0.00	73.80	17.21	23.29	135.39
November	20	0.00	191.50	56.65	53.09	93.73
December	20	12.00	283.00	110.17	64.18	58.25
January	20	23.70	198.90	105.16	48.22	45.85
February	20	5.00	226.20	86.19	63.29	73.43
March	20	25.90	545.00	124.50	110.00	88.35
April	20	11.40	136.30	69.62	35.83	51.46
May	20	0.00	118.00	19.44	26.36	135.60
Amadiya						
October	18	0.00	145.00	20.01	37.02	185.01
November	18	21.90	205.50	98.95	55.22	55.80
December	18	10.00	524.00	142.31	147.91	103.94
January	18	0.50	418.50	116.31	98.00	84.26
February	18	0.00	290.80	138.55	67.59	48.79
March	18	57.00	492.00	159.73	98.65	61.76
April	18	51.80	437.50	162.10	99.78	61.55
May	18	0.00	174.80	55.84	52.31	93.69
Zakho						
October	13	0.00	49.40	19.85	15.82	79.69
November	13	0.00	196.10	64.33	53.95	83.86
December	13	41.00	354.40	131.41	81.36	61.91
January	13	5.90	209.00	105.92	50.23	47.42
February	13	32.00	247.70	112.30	71.15	63.36
March	13	37.60	190.40	117.41	49.88	42.48
April	13	40.00	243.00	114.54	55.90	48.81
May	13	2.60	211.50	51.32	56.51	110.32

Appendix H, Table H.7 (Cont.)

	No.of cases	Minimum	Maximum	Mean	St. Dev.	% Coefficient of Variation
Kirkuk						
October	27	0.00	27.40	4.12	6.02	146.07
November	27	0.50	146.60	36.13	36.62	101.35
December	27	12.20	162.40	60.71	34.29	56.48
January	27	1.30	161.90	62.09	42.02	67.67
February	27	3.30	155.80	67.66	40.90	60.45
March	27	13.90	286.60	72.75	60.73	83.49
April	27	0.90	144.40	56.69	37.26	65.73
May	27	0.20	149.20	24.04	36.87	153.41
Hawija						
October	27	0.00	16.20	3.17	4.36	137.46
November	27	0.00	111.60	26.02	28.53	109.66
December	27	11.40	78.70	40.28	18.82	46.73
January	27	5.10	128.20	40.98	29.65	72.36
February	27	0.00	83.20	40.35	25.08	62.15
March	27	5.50	146.80	42.01	37.69	89.71
April	27	0.00	136.50	45.43	32.92	72.47
May	27	0.00	87.70	17.18	27.57	160.44
Iftikhar						
October	21	0.00	14.30	2.51	4.47	178.53
November	21	0.00	110.70	26.97	32.79	121.60
December	21	0.00	135.10	40.31	35.03	86.90
January	21	0.00	139.90	40.96	35.08	85.64
February	21	0.00	97.90	37.88	34.19	90.27
March	21	0.00	227.80	41.51	48.83	117.63
April	21	0.00	107.20	42.41	37.27	87.87
May	21	0.00	83.90	11.10	22.85	205.87
Tuz-Khurmatu						
October	21	0.00	40.60	2.93	8.96	305.90
November	21	0.00	151.80	23.75	35.25	148.40
December	21	0.00	113.00	46.06	32.78	71.16
January	21	7.50	176.50	36.66	38.25	104.32
February	21	0.00	117.10	38.65	35.61	92.15
March	21	0.00	240.20	50.78	57.58	113.84
April	21	0.00	106.10	40.73	38.91	95.52
May	21	0.00	91.40	14.03	24.37	173.63

Appendix H, Table H.7 (Cont.)

	No.of cases	Minimum	Maximum	Mean	St. Dev.	% Coefficient of Variation
Shaqlawa						
October	27	0.00	109.20	16.42	27.30	166.32
November	27	0.00	217.80	88.23	70.55	79.96
December	27	5.00	782.00	169.82	158.95	93.60
January	27	18.70	424.40	139.68	98.58	70.57
February	27	46.90	545.20	200.91	114.33	56.91
March	27	40.00	452.90	161.52	91.92	56.91
April	27	20.00	403.80	122.04	75.95	62.23
May	27	0.00	151.20	37.81	37.96	100.40
Arbil						
October	23	0.00	26.50	5.57	6.74	120.94
November	23	6.50	121.20	38.09	25.89	67.97
December	23	18.30	161.30	66.91	34.21	51.13
January	23	5.20	156.70	73.04	41.77	57.19
February	23	5.70	139.50	79.00	39.55	50.05
March	23	21.80	219.10	79.72	49.29	61.83
April	23	3.50	237.40	58.38	50.03	85.71
May	23	0.00	108.10	35.63	32.13	90.18
Rawnduz						
October	22	0.00	118.30	23.62	24.62	104.24
November	22	0.00	303.00	91.45	84.13	91.99
December	22	0.00	289.00	125.90	65.36	51.92
January	22	15.00	260.70	133.48	62.72	46.99
February	22	57.50	491.00	177.05	88.15	49.79
March	22	67.00	351.00	165.42	84.33	50.98
April	22	24.80	259.00	140.27	62.48	44.54
May	22	0.00	303.10	67.14	73.90	110.08
Salahuddin						
October	21	0.00	99.80	11.71	23.81	203.32
November	21	15.20	353.90	91.19	75.20	82.46
December	21	2.20	304.20	105.04	74.85	71.25
January	21	26.10	384.10	111.80	81.39	72.80
February	21	8.90	261.30	96.60	61.55	63.72
March	21	6.00	270.90	94.41	65.17	69.03
April	21	2.50	306.10	93.77	75.07	80.06
May	21	0.00	244.30	49.95	58.10	116.30

Appendix H, Table H.7 (Cont.)

	No.of cases	Minimum	Maximum	Mean	St. Dev.	% Coefficient of Variation
Dokan						
October	26	0.00	28.50	6.47	8.44	130.55
November	26	0.00	204.70	84.79	62.64	73.88
December	26	4.00	326.00	116.47	71.30	61.21
January	26	13.30	421.30	133.68	84.00	62.83
February	26	35.00	383.10	144.75	86.45	59.72
March	26	15.00	378.00	130.64	77.03	58.96
April	26	15.30	345.50	130.74	79.70	60.96
May	26	0.00	198.00	52.13	52.90	101.48
Sulaimaniya						
October	23	0.00	111.00	14.47	24.84	171.66
November	23	0.00	216.00	72.89	58.09	79.69
December	23	18.00	194.00	102.05	49.42	48.43
January	23	42.80	209.60	115.47	56.12	48.60
February	23	18.70	224.30	115.23	57.60	49.98
March	23	29.00	423.70	125.33	92.54	73.83
April	23	21.20	275.20	118.72	58.02	48.87
May	23	0.00	197.00	44.74	46.30	103.48
Halabja						
October	19	0.00	75.00	9.46	17.32	182.99
November	19	0.00	204.00	73.62	59.52	80.85
December	19	9.00	191.80	99.74	47.99	48.11
January	19	1.90	369.00	117.89	80.65	68.41
February	19	18.00	228.10	98.10	61.72	62.92
March	19	39.60	239.00	106.62	52.25	49.00
April	19	7.50	186.50	91.77	49.51	53.95
May	19	0.00	136.50	30.12	42.03	139.57
Bakrajo						
October	20	0.00	45.00	8.98	12.18	135.63
November	20	11.60	216.00	88.16	58.50	66.35
December	20	0.00	235.90	106.45	64.96	61.02
January	20	23.50	225.00	116.11	53.13	45.76
February	20	24.50	222.60	107.06	54.36	50.77
March	20	29.00	275.00	123.69	72.01	58.22
April	20	29.00	247.70	128.46	58.38	45.44
May	20	0.00	210.50	54.42	60.95	112.01

Appendix H, Table H.7 (Cont.)

	No.of cases	Minimum	Maximum	Mean	St. Dev.	% Coefficient of Variation
Penjwin						
October	12	0.00	55.90	13.68	18.24	133.37
November	12	0.00	498.60	117.97	147.47	125.01
December	12	29.00	348.70	205.37	88.43	43.06
January	12	67.00	421.50	181.46	107.76	59.38
February	12	92.00	479.50	238.39	125.61	52.69
March	12	84.20	441.00	226.75	124.21	54.78
April	12	43.00	314.00	161.41	87.07	53.94
May	12	0.00	233.00	56.43	68.37	121.17
Chwarta						
October	11	0.00	19.00	5.62	6.96	123.80
November	11	0.00	221.50	73.93	72.32	97.82
December	11	25.70	198.40	110.56	61.57	55.69
January	11	52.30	232.90	140.33	54.84	39.08
February	11	22.70	442.00	146.41	131.36	89.72
March	11	31.40	336.40	143.81	106.79	74.26
April	11	2.50	236.10	105.23	78.19	74.31
May	11	0.00	155.50	36.69	45.97	125.28

APPENDIX I, TABLE I.1
REGRESSION OF WHEAT YIELD ON TOTAL RAINFALL IN THE RAINFED AREA OF NORTHERN IRAQ(MM)*

	STATION	PROVINCE	PERIOD ONE 1949/50-1975/76 FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD TWO 1949/50-1957/58 FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1	SINJAR	NINEVEH	Y = 59.69 + 0.18TR (2.91)	27	.49	.24	52.89	7.97	Y = -1.36 + 0.28TR (3.15)	9	.77	.59	41.42	9.95
2	MOSUL	NINEVEH	Y = 23.40 + 0.26TR (2.71)	27	.49	.23	53.30	7.36	Y = -25.47 + 0.37TR (2.96)	9	.75	.55	42.94	8.73
3	TELAFAR	NINEVEH	Y = 25.12 + 0.33TR (3.99)	27	.62	.39	47.40	15.92	Y = -58.03 + 0.62TR (3.37)	9	.79	.62	39.79	11.37
4	AQRA	NINEVEH	Y = 49.67 + 0.09TR (1.97)	20	.40	.16	60.92	3.50	Y = -23.66 + 0.16TR (2.26)	9	.75	.56	51.99	5.09
5	SERSANK	NINEVEH	Y = 80.16 + 0.05TR (2.20)	20	.46	.21	45.86	4.85	Y = 84.64 + 0.04TR (0.91)	9	.32	.11	60.93	0.83
6	DUHUK	NINEVEH	Y = 37.78 + 0.15TR (2.64)	20	.53	.28	44.89	6.95	Y = -75.87 + 0.35TR (3.05)	8	.79	.61	42.91	9.33
7	AMADIYA	NINEVEH	Y = 135.27 + 0.01TR (0.19)	18	.05	.002	66.95	0.37	Y = -171.44 + 0.40TR (4.72)	8	.89	.79	31.59	22.38
8	ZAKHO	NINEVEH	Y = -56.22 + 0.29TR (3.09)	13	.68	.46	56.79	9.52	Y = -99.34 + 0.33TR (2.77)	7	.78	.61	46.62	7.67
9	KIRKUK	KIRKUK	Y = 17.26 + 0.29TR (3.34)	27	.55	.31	49.19	11.12	Y = -18.99 + 0.40TR (3.72)	9	.81	.66	38.53	13.92
10	HAWIJA	KIRKUK	Y = 12.82 + 0.46TR (4.21)	27	.64	.42	45.20	17.76	Y = -2.98 + 0.54TR (4.50)	9	.86	.74	33.66	20.29
11	IFTIKHAR	KIRKUK	Y = 31.03 + 0.38TR (4.77)	21	.74	.55	35.74	22.73	Y = 15.41 + 0.42TR (4.50)	9	.86	.74	33.67	20.26
12	TUZ-KHURMATU	KIRKUK	Y = 81.45 + 0.21TR (2.29)	21	.47	.22	56.29	5.26	Y = 28.80 + 0.38TR (4.40)	7	.89	.79	34.67	19.37
13	SHAQLAWA	ARBIL	Y = 76.12 + 0.05TR (2.15)	27	.40	.16	40.66	4.63	Y = 67.15 + 0.07TR (1.12)	9	.39	.15	49.71	1.24
14	ARBIL	ARBIL	Y = 80.59 + 0.10TR (1.43)	23	.30	.09	39.83	2.04	Y = 75.58 + 0.14TR (0.91)	9	.32	.11	50.99	.83
15	RAWNDUZ	ARBIL	Y = 67.98 + 0.06TR (1.60)	22	.34	.11	43.55	2.57	Y = 44.19 + 0.09TR (1.47)	9	.49	.24	47.14	2.17
16	SALAHUDDIN	ARBIL	Y = 98.72 + 0.04TR (0.86)	21	.19	.04	40.01	0.75	Y = -83.36 + 0.32TR (3.74)	4	.94	.88	24.53	14.02
17	DOKAN	SULAIMANIYA	Y = 140.53 + 0.04TR (0.70)	26	.16	.03	57.45	0.63	Y = 128.77 + 0.06TR (0.73)	8	.29	.08	70.53	0.53
18	SULAIMANIYA	SULAIMANIYA	Y = 156.96 + 0.01TR (0.33)	23	.03	.01	59.70	0.02	Y = 98.30 + 0.11TR (0.82)	8	.32	.10	73.98	0.68
19	HALABJA	SULAIMANIYA	Y = 141.28 + 0.02TR (0.25)	19	.06	.004	60.01	0.06	Y = 46.32 + 0.21TR (1.73)	9	.55	.30	60.56	3.00
20	BAKRAJO	SULAIMANIYA	Y = 150.67 + 0.01TR (0.19)	20	.05	.002	63.89	0.04	Y = 110.06 + 0.09TR (0.60)	6	.29	.08	29.90	0.36
21	PENJWIN	SULAIMANIYA	Y = 105.37 + 0.05TR (1.13)	12	.34	.11	58.10	1.27	Y = 86.05 + 0.07TR (1.08)	9	.38	.14	67.03	1.16
22	CHWARTA	SULAIMANIYA	Y = 59.03 + 0.14TR (2.38)	11	.62	.39	49.46	5.68	Y = 34.80 + 0.16TR (2.00)	7	.67	.44	61.86	3.99

	STATION	PROVINCE	PERIOD THREE 1963/64-1975/76 FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD FOUR 1949/50-1957/58 & 1963/64-1975/67 FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1	SINJAR	NINEVEH	Y = 58.52 + 0.21TR (2.17)	13	.55	.30	56.16	4.69	Y = 40.06 + 0.22TR (3.34)	22	.60	.36	50.76	11.17
2	MOSUL	NINEVEH	Y = 12.62 + 0.34TR (2.31)	13	.57	.33	55.02	5.35	Y = 2.13 + 0.36TR (3.47)	22	.61	.38	50.09	12.02
3	TELAFAR	NINEVEH	Y = 3.66 + 0.39TR (4.30)	13	.79	.63	40.95	18.50	Y = -4.19 + 0.42TR (5.50)	22	.76	.60	40.00	30.20
4	AQRA	NINEVEH	Y = 55.29 + 0.10TR (1.49)	13	.41	.17	61.21	2.21	Y = 28.76 + 0.12TR (2.46)	19	.51	.26	57.69	6.04
5	SERSANK	NINEVEH	Y = 91.31 + 0.05TR (1.78)	7	.62	.39	33.89	3.15	Y = 84.96 + 0.05TR (1.82)	16	.44	.19	43.36	3.31
6	DUHOK	NINEVEH	Y = 62.66 + 0.09TR (1.24)	7	.48	.23	41.27	1.53	Y = 31.18 + 0.15TR (2.32)	15	.54	.29	46.29	5.39
7	AMADIYA	NINEVEH	Y = 204.51 - 0.04TR (0.66)	8	.26	.07	71.13	0.43	Y = 128.75 + 0.02TR (0.41)	16	.11	.01	68.72	0.17
8	ZAKHO	NINEVEH	Y = 17.22 + 0.21TR (1.32)	6	.55	.30	71.22	1.74	Y = -56.22 + 0.29TR (3.09)	13	.68	.46	56.79	9.52
9	KIRKUK	KIRKUK	Y = 17.67 + 0.31TR (2.04)	13	.52	.27	53.72	4.16	Y = -1.10 + 0.35TR (3.99)	22	.68	.43	46.22	15.11
10	HAWIJA	KIRKUK	Y = -18.99 + 0.59TR (3.46)	13	.72	.52	43.66	11.95	Y = -9.85 + 0.56TR (5.63)	22	.79	.61	39.10	31.67
11	IFTIKHAR	KIRKUK	Y = 33.96 + 0.36TR (1.43)	7	.54	.29	38.77	2.04	Y = 23.16 + 0.40TR (4.92)	16	.80	.63	33.47	24.25
12	TUZ-KHURMATU	KIRKUK	Y = 105.89 + 0.19TR (0.82)	10	.29	.08	64.61	0.67	Y = 79.10 + 0.27TR (2.55)	17	.55	.30	55.26	6.49
13	SHAQLAWA	ARBIL	Y = 73.77 + 0.05TR (2.31)	13	.57	.33	31.05	5.32	Y = 76.76 + 0.05TR (2.26)	22	.45	.20	33.03	5.10
24	ARBIL	ARBIL	Y = 76.20 + 0.10TR (1.18)	13	.34	.11	35.63	1.39	Y = 91.53 + 0.10TR (1.39)	22	.30	.09	40.70	1.92
15	RAWNDUZ	ARBIL	Y = 77.49 + 0.06TR (1.37)	8	.49	.24	33.66	1.97	Y = 61.79 + 0.07TR (2.08)	17	.47	.25	38.93	4.34
16	SALAHUDIN	ARBIL	Y = 116.63 + 0.002TR (0.05)	12	.01	.00	33.32	0.00	Y = 90.12 + 0.04TR (0.90)	16	.23	.55	37.50	0.81
17	DOKAN	SULAIMANIYA	Y = 138.34 + 0.05TR (0.86)	13	.25	.06	43.99	0.75	Y = 134.47 + 0.05TR (1.22)	21	.27	.07	51.93	1.48
18	SULAIMANIYA	SULAIMANIYA	Y = 154.33 - 0.02TR (0.35)	10	.12	.02	42.77	0.13	Y = 130.89 + 0.06TR (0.91)	18	.22	.05	55.29	0.93
19	HALABJA	SULAIMANIYA	Y = 105.50 + 0.06TR (1.28)	5	.59	.35	20.28	1.64	Y = 91.14 + 0.11TR (1.47)	14	.39	.15	55.70	2.16
20	BAKRAJO	SULAIMANIYA	Y = 149.17 + 0.02TR (0.25)	9	.09	.01	45.71	0.06	Y = 124.90 + 0.06TR (0.85)	15	.23	.05	60.86	0.73
21	PENJWIN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE EQUATION						Y = 86.05 + 0.07TR (1.08)	9	.39	.14	67.50	1.16
22	CHWARTA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE EQUATION						Y = 34.80 + 0.16TR (2.00)	7	.67	.44	61.86	3.99

* TR=TOTAL RAINFALL VALUE IN BRACKETS IS THE T-VALUE

APPENDIX I, TABLE I.2
REGRESSION OF WHEAT YIELD ON MONTHLY RAINFALL(MM) IN THE RAINFED AREA OF NORTHERN IRAQ

STATION	PROVINCE	PERIOD ONE 1949/50-1975/76 FUNCTION	NO. OF CASES	R	R²	S.E.	F-VALUE	PERIOD TWO 1949/50-1957/58 FUNCTION	NO. OF CASES	R	R²	S.E.	F-VALUE
1 SINJAR	NINEVEH	Y = 75.05 + 0.67R2 + 0.61R7 (1.73) (2.87)	27	.59	.35	49.82	6.52	Y = 67.06 + 0.98R7 (3.06)	9	.76	.52	42.15	9.37
2 MOSUL	NINEVEH	Y = 35.68 + 1.27R2 + 0.75R6 (3.71) (3.52)	27	.68	.49	45.40	10.30	Y = -6.13 + 1.57R2 + 1.11R6 (2.44) (4.61)	9	.90	.81	30.40	12.73
3 TELAFAR	NINEVEH	Y = 43.49 + 0.67R3 + 0.57R5 + 0.46R6 (2.46) (2.18) (1.99)	27	.65	.42	47.97	5.65	Y = 74.97 + 1.02R6 - 1.18R8 (5.04) (2.17)	9	.91	.82	29.44	13.78
4 AGRA	NINEVEH	Y = 77.93 + 0.56R2 (1.82)	20	.39	.16	61.17	3.32	Y = 26.85 + 0.78R4 (6.44)	6	.95	.91	23.26	41.42
5 SERSANK	NINEVEH	Y = 90.03 + 0.18R2 + 0.17R6 (1.88) (1.81)	20	.60	.36	42.41	4.86	NO SIGNIFICANT VARS IN THE FUNCTION					
6 DOHUK	NINEVEH	Y = 91.92 + 0.57R2 (3.06)	20	.58	.34	42.99	9.33	Y = -34.22 + 5.73R1 + 0.32R2 - 0.14R5 (12.24) (4.60) (3.59)					
								+ 1.29R6 (22.54)	9	.99	.99	5.88	203.16
7 AMADIYA	NINEVEH	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 28.91 + 0.67R6 (2.28)	8	.68	.46	50.19	5.20
8 ZAKHO	NINEVEH	Y = -27.12 + 2.28R1 + 1.11R6 (2.12) (3.25)	13	.73	.54	55.27	5.83	Y = 86.33 - 0.88R4 + 1.00R6 (2.62) (5.84)	7	.95	.90	26.49	17.62
9 KIRKUK	KIRKUK	Y = 92.49 + 0.65R7 (2.30)	27	.42	.17	53.71	5.28	Y = 58.25 + 0.93R6 (5.18)	9	.89	.79	30.24	26.79
10 HAWIJA	KIRKUK	Y = 87.11 + 1.01R6 (4.31)	27	.65	.43	44.76	18.61	Y = 89.92 - 7.21R1 + 1.00R6 (2.48) (7.96)	9	.97	.94	18.14	43.95
11 IFTIKHAR	KIRKUK	Y = 54.69 + 0.67R2 + 0.62R6 + 0.47R7 (2.84) (4.16) (2.28)	21	.88	.73	29.20	15.17	Y = 49.32 + 0.68R5 + 0.95R7 + 0.98R8 (2.83) (4.10) (2.79)	9	.97	.93	20.54	22.76
12 TUZ-KHURMATU	KIRKUK	Y = 109.87 + 0.75R6 - 0.94R8 (3.40) (1.80)	21	.63	.39	50.92	5.82	Y = 61.80 + 0.94R6 + 0.59R7 - 1.75R8 (8.97) (5.09) (5.76)	7	.99	.99	8.04	150.10
13 SHAQLAWA	ARBIL	Y = 55.38 + 0.29R2 + 0.14R5 + 0.32R8 (3.02) (2.30) (1.76)	27	.66	.44	34.56	6.00	NO SIGNIFICANT VARS IN THE FUNCTION					
14 ARBIL	ARBIL	Y = 116.92 - 2.89R1 + 0.31R6 (2.31) (1.80)	23	.50	.25	37.12	3.26	Y = 67.71 + 0.97R6 (2.13)	9	.63	.39	42.00	4.55
15 RAWNDUZ	ARBIL	Y = 102.21 + 0.23R2 (2.06)	22	.42	.18	42.01	4.26	NO SIGNIFICANT VARS IN THE FUNCTION					
16 SALAHUDDIN	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION						NO SIGNIFICANT VARS IN THE FUNCTION					
17 DOKAN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						NO SIGNIFICANT VARS IN THE FUNCTION					
18 SULAIMANIYA	SULAIMANIYA	Y = 163.11 + 0.43R2 - 0.43R4 + 0.31R6 (2.56) (2.51) (2.92)						Y = 123.25 - 1.25R1 + 1.05R2 (3.41) (5.00)	8	.92	.84	33.79	13.51
		- 0.48R8 (2.27)	23	.75	.56	43.00	5.62						
19 HALABJA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 63.40 + 1.36R2 + 0.80R8 (4.18) (2.10)	9	.86	.75	39.42	8.80
20 BAKRAJO	SULAIMANIYA	Y = 117.74 + 0.48R2 (2.16)	20	.45	.21	56.98	4.68	NO SIGNIFICANT VARS IN THE FUNCTION 1					
21 PENJWIN	SULAIMANIYA	Y = 133.77 + 0.28R2 (3.04)	12	.69	.48	44.47	9.24	Y = 127.28 + 0.30R2 (2.74)	9	.72	.52	50.26	7.51
22 CHWARTA	SULAIMANIYA	Y = 69.64 + 2.70R1 + 0.65R2 + 0.23R5 (2.95) (7.38) (4.64)	11	.96	.92	20.02	27.54	Y = 122.50 + 0.68R2 -0.40R3 + 0.27R5 (10.15) (4.02) (8.07)	7	.99	.99	10.67	99.71

STATION	PROVINCE	PERIOD THREE 1963/64-1975/76 FUNCTION	NO. OF CASES	R	R²	S.E.	F-VALUE	PERIOD FOUR 1949/50-1957/58 & 1963/64-1975/67 FUNCTION	NO. OF CASES	R	R²	S.E.	F-VALUE
1 SINJAR	NINEVEH	Y = 80.21 + 1.01R7 (3.10)	13	.68	.47	49.03	9.58	Y = 74.55 + 1.01R7 (4.48)	22	.71	.50	44.79	20.04
2 MOSUL	NINEVEH	Y = 92.37 + 0.87R7 (2.03)	13	.52	.27	57.19	4.13	Y = 33.44 + 1.27R2 + 0.81R6 (3.09) (3.67)	22	.73	.53	44.77	10.54
3 TELAFAR	NINEVEH	Y = 71.03 + 0.56R3 + 2.49R8 (2.01) (3.89)	13	.84	.71	38.16	11.98	Y = 13.33 + 1.02R2 + 0.74R5 + 0.81R6 (2.63) (3.09) (3.27)	22	.75	.56	44.36	7.60
4 AGRA	NINEVEH	Y = 95.04 + 1.36R8 (3.73)	13	.75	.56	44.55	13.93	Y = 56.04 + 0.28R4 + 1.21R8 (1.83) (3.20)	19	.71	.50	48.81	9.10
5 SERSANK	NINEVEH	Y = -75.89 + 0.21R7 + 3.37R8 (2.88) (4.43)	7	.91	.83	19.89	9.84	Y = 69.38 + 0.23R6 (2.04)	16	.48	.23	47.21	4.17
6 DOHUK	NINEVEH	Y = 84.50 + 0.51R2 (2.62)	7	.76	.58	30.59	6.89	Y = 94.62 + 0.53R2 (2.26)	15	.53	.28	46.64	5.10
7 AMADIYA	NINEVEH	Y = 211.02 + 5.01R1 + 0.11R3 + 0.08R4 (11.39) (5.79) (2.60)						NO SIGNIFICANT VARS IN THE FUNCTION					
		- 0.82R5 (12.95)	8	.99	.99	7.87	130.70						
8 ZAKHO	NINEVEH	Y = 14.24 + 0.57R4 + 2.04R8 (3.25) (6.94)	9	.97	.94	23.33	24.13	Y = -27.12 + 2.28R1 + 1.11R6 (2.12) (3.25)	13	.73	.54	55.27	5.83
9 KIRKUK	KIRKUK	Y = 137.65 - 4.32R1 - 0.70R2 + 2.83R8 (4.34) (2.86) (5.70)	13	.93	.86	26.45	17.85	Y = 99.32 - 3.07R1 + 0.34R6 + 1.09R8 (2.70) (2.31) (3.05)	22	.75	.56	43.07	7.48
10 HAWIJA	KIRKUK	Y = 90.71 - 4.48R1 + 0.72R6 + 3.73R8 (2.26) (2.56) (4.44)	13	.92	.85	27.02	16.98	Y = 90.54 - 5.35R1 + 0.80R6 + 0.46R7 (2.51) (3.61) (1.80)	22	.83	.69	35.65	13.67
11 IFTIKHAR	KIRKUK	Y = 110.49 - 3.42R1 + 0.73R2 (3.97) (4.82)	7	.97	.94	12.23	33.38	Y = -47.00 - 2.35R1 + 0.36R2 + 0.65R5 (2.83) (2.75) (5.04)					
12 TUZ-KHURMATU	KIRKUK							+ 0.87R7 + 1.09R8 (8.44) (5.46)	16	.98	.96	13.10	47.96
13 SHAQLAWA	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 104.38 + 0.69R6 (3.29)	17	.65	.42	50.49	10.75
14 ARBIL	ARBIL	Y = 96.92 - 0.35R1 +0.15R4 + 0.56R8 (2.09) (2.66) (3.85)	13	.89	.77	20.05	10.04	Y = 57.63 + 0.29R2 + 0.14R5 + 0.34R8 (2.75) (2.50) (1.95)	22	.72	.51	31.33	6.33
15 RAWNDUZ	ARBIL	Y = 95.20 + 0.76R8 (1.90)	13	.50	.25	32.80	3.62	NO SIGNIFICANT VARS IN THE FUNCTION					
16 SALAHUDDIN	ARBIL	Y = 190.09 - 0.42R1 - 0.63R2 + 1.44R3 (2.70) (4.57) (5.41)	8	.96	.93	12.31	16.77	Y = 99.36 + 0.31R3 (1.91)	17	.44	.20	33.62	3.66
17 DOKAN	SULAIMANIYA	Y = 103.62 - 0.47R1 + 0.78R8 (2.21) (4.44)	12	.83	.69	19.42	10.23	Y = 101.85 + 0.31R8 (2.27)	16	.52	.27	32.99	5.14
18 SULAIMANIYA	SULAIMANIYA	Y = 155.07 + 0.53R8 (2.07)	13	.53	.28	33.59	4.27	NO SIGNIFICANT VARS IN THE FUNCTION					
		NO SIGNIFICANT VARS IN THE FUNCTION						Y = 193.46 - 1.14R1 + 0.75R2 - 0.39R3 (3.21) (4.03) (1.88)	18	.79	.63	37.10	7.79
19 HALABJA	SULAIMANIYA	Y = 69.22 + 0.60R6 (2.95)	5	.86	.74	12.77	8.71	Y = 125.66 + 0.56R2 (2.25)	14	.55	.30	49.90	5.09
20 BAKRAJO	SULAIMANIYA	Y = 143.28 - 0.47R3 + 1.24R8 (2.71) (4.12)	9	.86	.74	25.15	9.57	Y = 118.67 + 0.61R2 (2.37)	14	.55	.30	52.24	5.63
21 PENJWIN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 127.28 + 0.30R2 (2.74)	9	.72	.52	50.26	7.50
22 CHWARTA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 122.50 + 0.69R2 - 0.40R3 + 0.27R5 (10.15) (4.02) (8.07)	7	.99	.99	10.67	99.71

R1= OCTOBER RAINFALL
R1= OCTOBER RAINFALL
R2= NOVEMBER RAINFALL
R3= DECEMBER RAINFALL
R4= JANUARY RAINFALL
R5= FEBRUARY RAINFALL
R6= MARCH RAINFALL
R7= APRIL RAINFALL
R8= MAY RAINFALL

VALUE IN BRACKETS IS THE T-VALUE

APPENDIX I, TABLE I.3
REGRESSION OF WHEAT YIELD ON MONTHLY AND TOTAL RAINFALL IN THE RAINFED AREA OF NORTHERN IRAQ(MM)

PERIOD ONE
1949/50-1975/76

STATION	PROVINCE	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1 SINJAR	NINEVEH	Y = 75.05 + 0.67R2 (1.73) + 0.61R7 (2.87)	27	.59	.35	43.82	6.52
2 MOSUL	NINEVEH	Y = 10.76 + 0.80R2 (2.39) - 0.56R8 (1.99) + 0.28TR (3.41)	27	.69	.48	45.59	7.08
3 TELAFAR	NINEVEH	Y = 15.52 - 0.71R8 (2.33) + 0.41TR (4.90)	27	.71	.50	43.69	12.08
4 AGRA	NINEVEH	Y = 49.67 + 0.09TR (1.87)	20	.40	.16	50.92	3.49
5 SERSANK	NINEVEH	Y = 80.03 + 0.19R2 (1.88) + 0.17R6 (1.91)	20	.60	.36	42.41	4.96
6 DOHUK	NINEVEH	Y = 41.40 + 0.43R2 (2.29) + 0.10TR (1.92)	20	.67	.45	40.37	6.92
7 AMADIYA	NINEVEH	NO SIGNIFICANT VARS IN THE FUNCTION					
8 ZAKHO	NINEVEH	Y =-131.90 - 0.63R3 (2.42) + 0.51TR (4.25)	13	.81	.66	47.26	9.81
9 KIRKUK	KIRKUK	Y = 38.48 - 2.84R1 (1.83) + 0.27TR (3.15)	27	.63	.39	47.01	7.77
10 HAWIJA	KIRKUK	Y = 34.34 + 0.62R6 (2.15) + 0.27TR (2.02)	27	.71	.51	42.23	12.49
11 IFTIKHAR	KIRKUK	Y = 47.36 - 3.23R1 (2.53) - 0.34R3 (1.98) - 0.46R4 (2.47) - 0.87R8 (3.01) + 0.50TR (7.16)	21	.90	.81	25.89	12.91
12 TUZ-KHURMATU	KIRKUK	Y = 109.87 + 0.75R6 (3.40) - 0.94R8 (1.80)	21	.63	.39	50.92	5.92
13 SHAQLAWA	ARBIL	Y = 55.38 + 0.29R2 (3.02) + 0.14R5 (2.31) + 0.32R8 (1.76)	27	.66	.44	34.56	6.00
14 ARBIL	ARBIL	Y = 79.45 - 2.72R1 (2.30) + 0.14TR (2.08)	23	.53	.28	36.29	3.87
15 RAWNDUZ	ARBIL	Y = 102.21 + 0.23R2 (2.06)	22	.42	.18	42.01	4.26
16 SALAHUDDIN	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION					
17 DOKAN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION					
18 SULAIMANIYA	SULAIMANIYA	Y = 163.11 + 0.43R2 (2.56) - 0.43R4 (2.51) + 0.31R6 (2.92) - 0.49R8 (2.21)	23	.75	.56	46.00	5.62
19 HALABJA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION					
20 BAKRAJO	SULAIMANIYA	Y = 117.74 + 0.48R2 (2.16)	20	.45	.21	56.98	4.68
21 PENJWIN	SULAIMANIYA	Y = 133.77 + 0.28R2 (3.04)	12	.69	.48	44.47	9.24
22 CHWARTA	SULAIMANIYA	Y = 69.64 + 2.70R1 (2.75) + 0.65R2 (7.38) + 0.23R5 (4.67)	11	.96	.92	20.02	27.54

PERIOD TWO
1949/50-1957/58

STATION	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1 SINJAR	Y = -1.36 + 0.28TR (3.15)	9	.77	.59	41.42	9.95
2 MOSUL	Y = -6.13 + 1.57R2 (2.44) + 1.11R6 (4.61)	9	.90	.81	30.40	12.73
3 TELAFAR	Y = 74.97 + 1.02R6 (5.04) - 1.18R8 (2.17)	9	.91	.82	29.44	13.79
4 AGRA	Y = 26.85 + 0.78R4 (6.44)	6	.95	.91	23.26	41.42
5 SERSANK	NO SIGNIFICANT VARS IN THE FUNCTION					
6 DOHUK	Y = -34.22 + 5.73R1 (12.24) + 0.32R2 (4.60) - 0.14R5 (3.53) + 1.29R6 (22.54)	8	.99	.99	5.39	203.16
7 AMADIYA	Y =-171.44 + 0.40TR (4.72)	8	.89	.79	31.58	22.28
8 ZAKHO	Y = 86.33 - 0.88R4 (2.62) + 1.00R6 (5.94)	7	.95	.90	26.49	17.62
9 KIRKUK	Y = 59.25 + 0.93R6 (5.18)	9	.89	.79	30.24	26.79
10 HAWIJA	Y = 89.92 - 7.21R1 (2.49) + 1.00R6 (7.96)	9	.97	.94	18.14	47.35
11 IFTIKHAR	Y = 0.42 - 1.17R4 (3.63) - 1.14R8 (2.11) + 0.68TR (7.93)	9	.98	.96	16.09	39.15
12 TUZ-KHURMATU	Y = 29.80 + 0.35TR (4.10)	7	.89	.79	34.67	19.37
13 SHAQLAWA	NO SIGNIFICANT VARS IN THE FUNCTION					
14 ARBIL	Y = 67.71 + 0.87R6 (2.13)	9	.63	.39	42.00	4.55
15 RAWNDUZ	NO SIGNIFICANT VARS IN THE FUNCTION					
16 SALAHUDDIN	Y =-127.78 +17.58R1 (211.14) + 0.37TR (596.28)	4	1.00	1.00	33.16	479.49
17 DOKAN	NO SIGNIFICANT VARS IN THE FUNCTION					
18 SULAIMANIYA	Y = 123.25 - 1.47R1 (3.41) + 1.05R2 (5.00)	9	.92	.84	23.79	13.51
19 HALABJA	Y = 63.40 + 1.36R2 (4.18) + 0.80R8 (2.10)	9	.86	.75	34.42	9.20
20 BAKRAJO	NO SIGNIFICANT VARS IN THE FUNCTION					
21 PENJWIN	Y = 127.28 + 0.30R2 (2.74)	9	.72	.52	50.26	7.61
22 CHWARTA	Y = 122.50 + 0.68R2 (10.15) - 0.40R3 (4.02) + 0.27R5 (9.07)	7	.99	.99	10.67	99.71

PERIOD THREE
1963/64-1975/76

STATION	PROVINCE	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1 SINJAR	NINEVEH	Y = 80.21 + 1.02R7 (3.10)	13	.68	.47	49.03	9.58
2 MOSUL	NINEVEH	Y = 12.62 + 0.37TR (2.31)	13	.57	.33	55.02	5.35
3 TELAFAR	NINEVEH	Y = 23.26 + 1.70R8 (2.57) + 0.26TR (2.90)	13	.88	.73	33.33	17.27
4 AGRA	NINEVEH	Y = 95.04 + 1.36R8 (3.73)	13	.75	.56	44.55	13.93
5 SERSANK	NINEVEH	Y = -75.89 + 0.21R7 (2.88) + 3.37R8 (4.43)	7	.91	.83	19.89	9.84
6 DOHUK	NINEVEH	Y = 84.50 + 0.51R2 (2.62)	7	.76	.58	30.59	6.99
7 AMADIYA	NINEVEH	Y = 211.02 + 5.01R1 (11.99) + 0.11R3 (5.79) + 0.08R4 (2.60) - 0.82R5 (12.95)	8	.99	.99	7.87	130.70
8 ZAKHO	NINEVEH	Y = 16.24 + 0.57R4 (3.25) + 2.04R8 (6.94)	6	.97	.94	23.83	24.13
9 KIRKUK	KIRKUK	Y = 137.65 - 4.32R1 (4.34) - 0.70R2 (2.86) + 2.83R8 (5.70)	13	.93	.86	26.45	17.95
10 HAWIJA	KIRKUK	Y = 90.71 - 4.48R1 (2.26) + 0.72R6 (2.56) + 3.83R8 (4.44)	13	.92	.85	27.02	16.98
11 IFTIKHAR	KIRKUK	Y = 110.49 - 3.42R1 (3.97) + 0.73R2 (4.82)	7	.92	.94	12.23	33.39
12 TUZ-KHURMATU	KIRKUK	NO SIGNIFICANT VARS IN THE FUNCTION					
13 SHAQLAWA	ARBIL	Y = 57.22 + 0.59R8 (3.74) + 0.04TR (2.82)	13	.85	.72	21.01	12.82
14 ARBIL	ARBIL	Y = 95.20 + 0.76R8 (1.90)	13	.50	.25	32.80	3.62
15 RAWNDUZ	ARBIL	Y = 140.09 - 0.45R1 (2.70) - 0.63R2 (4.57) + 1.44R8 (6.41)	8	.96	.92	12.81	16.77
16 SALAHUDDIN	ARBIL	Y = 103.62 - 0.47R1 (2.21) + 0.78R8 (4.44)	12	.83	.69	19.42	10.23
17 DOKAN	SULAIMANIYA	Y = 155.07 + 0.53R8 (2.07)	13	.53	.28	38.59	4.27
18 SULAIMANIYA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION					
19 HALABJA	SULAIMANIYA	Y = 69.22 + 0.60R6 (2.95)	5	.86	.74	12.77	8.71
20 BAKRAJO	SULAIMANIYA	Y = 143.28 - 0.47R3 (2.71) + 1.24R8 (4.12)	9	.86	.74	25.25	8.57
21 PENJWIN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION					
22 CHWARTA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION					

PERIOD FOUR
1949/50-1957/58 & 1963/64-1975/67

STATION	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1 SINJAR	Y = 74.55 + 1.01R7 (4.48)	22	.71	.50	44.79	20.06
2 MOSUL	Y = -14.99 + 0.32R2 (2.18) + 0.31TR (3.44)	22	.71	.50	45.96	9.51
3 TELAFAR	Y = -4.19 + 0.42TR (5.60)	22	.78	.60	40.00	30.20
4 AGRA	Y = 56.04 + 0.28R4 (1.83) + 1.21R8 (3.20)	19	.71	.50	48.81	8.10
5 SERSANK	Y = 89.38 + 0.23R6 (2.04)	15	.48	.23	47.21	4.17
6 DOHUK	Y = 31.18 + 0.15TR (2.32)	15	.54	.29	46.29	5.39
7 AMADIYA	NO SIGNIFICANT VARS IN THE FUNCTION					
8 ZAKHO	Y =-131.90 - 0.63R3 (2.42) + 0.51TR (4.25)	13	.81	.66	47.26	9.81
9 KIRKUK	Y = 21.19 - 2.90R1 (1.88) + 0.32TR (3.74)	22	.72	.52	43.55	10.23
10 HAWIJA	Y = 40.98 - 4.35R1 (2.07) + 0.50R6 (1.85) + 0.33TR (2.37)	22	.85	.73	33.82	15.96
11 IFTIKHAR	Y = 40.35 - 3.63R4 (3.12) + 0.53R7 (3.04) + 0.34TR (4.36)	16	.93	.87	21.55	26.75
12 TUZ-KHURMATU	Y = 104.38 + 0.69R6 (3.28)	17	.65	.42	50.49	10.75
13 SHAQLAWA	Y = 57.63 + 0.29R2 (2.75) + 0.14R5 (2.50) + 0.34R8 (1.95)	22	.75	.51	31.37	6.33
14 ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION					
15 RAWNDUZ	Y = 61.78 + 0.73TR (2.08)	17	.47	.22	39.93	4.24
16 SALAHUDDIN	Y = 101.58 + 0.31R8 (2.27)	16	.52	.27	32.99	5.14
17 DOKAN	NO SIGNIFICANT VARS IN THE FUNCTION					
18 SULAIMANIYA	Y = 183.46 - 1.14R1 (3.21) + 0.75R2 (4.03) - 0.33R3 (1.95)	13	.79	.63	37.09	7.79
19 HALABJA	Y = 125.66 + 0.57R2 (2.25)	14	.55	.30	48.89	5.08
20 BAKRAJO	Y = 118.67 + 0.61R2 (2.37)	15	.55	.30	52.24	5.63
21 PENJWIN	Y = 127.28 + 0.30R2 (2.74)	9	.72	.52	50.26	7.61
22 CHWARTA	Y = 122.50 + 0.69R2 (10.15) - 0.40R3 (4.02) + 0.27R5 (9.07)	7	.99	.99	10.67	99.71

TR=TOTAL RAINFALL
R1= OCTOBER RAINFALL
R1= OCTOBER RAINFALL
R2= NOVEMBER RAINFALL
R3= DECEMBER RAINFALL
R4= JANUARY RAINFALL
R5= FEBRUARY RAINFALL
R6= MARCH RAINFALL
R7= APRIL RAINFALL
R8= MAY RAINFALL

VALUE IN BRACKETS IS THE T-VALUE

APPENDIX I, TABLE I.4
REGRESSION OF WHEAT YIELD ON MONTHLY MINIMUM, MAXIMUM, MEAN AND SEASONAL TEMPERATURE IN THE RAINFED AREA OF NORTHERN IRAQ

MOSUL STATION

MAXIMUM TEMPERATURE FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = 1066.6 - 13.44MAT2 (2.71) - 29.49SMAT (3.73)	27	.71	.51	43.49	12.30	1
Y = 1373.8 - 6.99MAT3 (2.19) + 21.21MAT4 (5.71) - 64.14SMAT (7.87)	9	.98	.96	15.87	36.82	2
Y = 520.6 - 26.92MAT3 (3.02)	13	.67	.45	49.57	9.13	3
Y = 1239.0 + 16.41MAT5 (2.29) - 62.66SMAT (4.92)	22	.78	.60	40.95	14.45	4

MINIMUM TEMPERATURE	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
NO SIGNIFICANT VARS IN THE FUNCTION						1
Y = 703.2 - 83.52SMIT (2.50)	9	.69	.47	46.86	6.24	2
Y = 390.7 - 26.04MIT5 (2.78) + 23.64MIT7 (2.01) - 25.33MIT8 (2.66)	13	.81	.66	43.53	5.70	3
NO SIGNIFICANT VARS IN THE FUNCTION						4

MEAN TEMPERATURE	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = 734.8 - 41.21SMT (2.97)	27	.51	.26	52.12	8.84	1
Y = 867.3 - 52.88MT2 (5.33)	9	.90	.80	28.67	28.37	2
Y = 892.7 - 51.01SMT (2.35)	13	.58	.33	54.75	5.51	3
Y = 836.2 - 48.06SMT (3.33)	22	.60	.36	50.82	11.10	4

KIRKUK STATION

MAXIMUM TEMPERATURE FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = 1076.4 - 12.64MAT2 (2.85) - 29.53SMAT (3.29)	27	.70	.49	43.24	11.36	1
Y = 775.6 - 24.62MAT7 (4.38)	9	.86	.73	34.33	19.23	2
Y = 1316.5 - 14.85MAT2 (2.93) - 25.35MAT8 (3.58)	13	.84	.71	35.30	12.10	3
Y = 1163.1 - 11.53MAT2 (2.21) + 34.62SMAT (3.33)	22	.72	.52	43.70	10.14	4

MINIMUM TEMPERATURE	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = 266.6 - 22.43MIT3 (2.75)	27	.49	.23	51.81	7.55	1
Y = 1337.0 - 35.89MIT2 (5.21) - 13.70MIT5 (3.06) + 23.66MIT6 (6.48) - 69.04MIT7 (5.45)	9	.98	.97	15.42	31.48	2
NO SIGNIFICANT VARS IN THE FUNCTION						3
Y = 268.1 - 22.44MIT3 (2.50)	22	.49	.24	53.44	6.26	4

MEAN TEMPERATURE	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = 916.5 - 14.83MT2 (2.39) - 32.28SMT (2.64)	27	.64	.40	46.62	8.10	1
Y = 859.1 - 36.63MT7 (3.73)	9	.82	.67	38.45	13.90	2
Y = 867.4 + 14.87MT7 (1.99) - 61.59SMT (2.86)	13	.69	.47	48.13	4.44	3
Y = 965.5 - 14.58MT2 (1.99) - 35.50SMT (2.51)	22	.64	.41	48.21	6.64	4

MAT1= MAXIMUM OCTOBER TEMPERATURE
MAT2= MAXIMUM NOVEMBER TEMPERATURE
MAT3= MAXIMUM DECEMBER TEMPERATURE
MAT4= MAXIMUM JANUARY TEMPERATURE
MAT5= MAXIMUM FEBRUARY TEMPERATURE
MAT6= MAXIMUM MARCH TEMPERATURE
MAT7= MAXIMUM APRIL TEMPERATURE
MAT8= MAXIMUM MAY TEMPERATURE
SMAT= SEASONAL MAXIMUM TEMPERATURE

MIT1= MINIMUM OCTOBER TEMPERATURE
MIT2= MINIMUM NOVEMBER TEMPERATURE
MIT3= MINIMUM DECEMBER TEMPERATURE
MIT4= MINIMUM JANUARY TEMPERATURE
MIT5= MINIMUM FEBRUARY TEMPERATURE
MIT6= MINIMUM MARCH TEMPERATURE
MIT7= MINIMUM APRIL TEMPERATURE
MIT8= MINIMUM MAY TEMPERATURE
SMIT= SEASONAL MINIMUM TEMPERATURE

MT1= MEAN OCTOBER TEMPERATURE
MT2= MEAN NOVEMBER TEMPERATURE
MT3= MEAN DECEMBER TEMPERATURE
MT4= MEAN JANUARY TEMPERATURE
MT5= MEAN FEBRUARY TEMPERATURE
MT6= MEAN MARCH TEMPERATURE
MT7= MEAN APRIL TEMPERATURE
MT8= MEAN MAY TEMPERATURE
SMT= SEASONAL MEAN TEMPERATURE

VALUE IN BRACKETS IS THE T-VALUE

APPENDIX I, TABLE I.5
REGRESSION OF WHEAT YIELD ON MONTHLY RELATIVE HUMIDITY IN THE RAINFED AREA OF NORTHERN IRAQ

MOSUL STATION FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = -51.4 + 2.91RH7 (2.52)	27	.45	.20	54.14	6.36	1
Y = -508.4 + 3.79RH6 (3.88)	9	.83	.68	36.31	15.00	2
Y = 324.0 - 6.00RH5 (2.48) + 5.95RH8 (4.36)	13	.81	.66	41.03	9.70	3
Y = -75.4 + 3.39RH7 (2.75)	22	.52	.27	53.96	7.58	4

KIRKUK STATION FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = -54.6 + 3.59RH7 (3.02)	27	.52	.27	50.61	9.11	1
Y = -116.5 + 4.76RH7 (4.30)	9	.85	.72	34.84	18.45	2
Y = 58.9 - 3.37RH1 (2.87) + 5.57RH8 (4.81)	13	.87	.76	32.14	16.18	3
Y = -103.3 + 2.71RH7 (2.34) + 2.87RH8 (2.56)	22	.72	.76	32.14	16.18	4

RH1= OCTOBER RELATIVE HUMIDITY
RH2= NOVEMBER RELATIVE HUMIDITY
RH3= DECEMBER RELATIVE HUMIDITY
RH4= JANUARY RELATIVE HUMIDITY
RH5= FEBRUARY RELATIVE HUMIDITY
RH6= MARCH RELATIVE HUMIDITY
RH7= APRIL RELATIVE HUMIDITY
RH8= MAY RELATIVE HUMIDITY

VALUE IN BRACKETS IS THE T-VALUE

APPENDIX I TABLE I.6 WHEAT YIELDS(KG./DONUM) IN NINEVEH AND KIRKUK PROVINCES
ACTUAL AND FORECASTED

NINEVEH PROVINCE

PERIOD 1949/50-1975/76

YEAR	ACTUAL YIELD	TOTAL RAINFALL	MONTHLY RAINFALL	MONTHLY & TOTAL RAINFALL	MONTHLY MAX. TEMPERATURE	MONTHLY MIN. TEMPERATURE	MONTHLY MEAN TEMPERATURE	RELATIVE HUMIDITY	SELECTED VARIABLES
		FORECASTED YIELD							
1950	103.1	134.8	177.1	117.3	167.8		186.7	126.3	122.7
1951	53.8	88.9	84.4	66.2	45.0		112.6	114.7	5.9
1952	134.5	112.2	148.8	105.7	109.1		129.0	126.3	168.3
1953	135.9	130.2	38.2	143.5	112.1		133.2	164.2	119.6
1954	224.8	161.3	194.6	184.2	208.4		178.5	172.9	226.1
1955	31.6	108.9	123.4	110.6	50.9		79.6	114.7	70.6
1956	151.1	114.4	115.4	125.3	123.3		137.3	146.7	166.9
1957	180.8	149.7	151.2	143.3	149.1		174.4	146.7	153.9
1958	95.7	89.3	83.8	95.0	114.5		129.0	82.6	125.1
1959	70.5	115.9	126.9	85.2	155.5		166.1	117.6	88.6
1960	106.9	87.0	80.7	86.8	93.6		116.7	138.0	121.2
1961	154.8	105.4	91.0	103.7	128.5		133.2	146.7	122.4
1962	191.2	123.3	132.3	134.9	148.1		116.7	146.7	150.3
1963	76.6	187.7	114.9	113.9	88.9		96.1	170.1	105.7
1964	121.6	133.7	158.5	146.8	170.8		162.0	129.3	142.2
1965	140.7	137.6	135.4	153.0	135.9		129.0	152.6	167.1
1966	83.9	93.3	99.8	95.0	119.1		96.1	126.3	69.3
1967	64.9	120.3	141.4	117.1	72.8		116.7	114.7	81.4
1968	160.4	164.9	121.1	173.1	188.8		124.9	138.0	174.4
1969	156.1	215.7	185.7	248.7	147.2		100.2	164.2	176.8
1970	106.7	116.2	92.5	125.5	112.6		75.5	100.1	101.5
1971	101.9	109.4	94.8	115.8	83.6		104.3	138.0	92.4
1972	308.0	215.0	226.5	203.6	186.9		170.2	146.7	263.7
1973	109.2	91.2	78.5	84.5	141.3		120.8	50.6	84.1
1974	154.5	176.9	154.6	189.4	197.7		166.1	135.1	151.8
1975	100.9	114.6	119.6	112.2	150.9		141.4	108.9	98.5
1976	204.1	166.4	182.8	173.8	151.5		157.9	135.1	203.7

PERIOD 1949/50-191957/58 AND 1963/64-1975/76

YEAR	ACTUAL YIELD	TOTAL RAINFALL	MONTHLY RAINFALL	MONTHLY & TOTAL RAINFALL	MONTHLY MAX. TEMPERATURE	MONTHLY MIN. TEMPERATURE	MONTHLY MEAN TEMPERATURE	RELATIVE HUMIDITY	SELECTED VARIABLES
		FORECASTED YIELD							
1950	103.1	136.0	125.0	136.0	138.3		197.0	131.3	119.8
1951	53.8	77.3	70.1	77.3	44.9		110.5	117.8	53.3
1952	134.5	107.1	157.2	107.1	96.4		129.7	131.3	138.8
1953	135.9	130.2	145.1	130.2	91.1		134.5	175.4	128.5
1954	224.8	169.9	217.2	169.9	192.1		187.4	185.6	216.0
1955	31.6	103.0	108.7	103.0	39.1		72.0	117.8	44.1
1956	151.1	109.9	102.6	109.9	136.5		139.3	155.1	156.6
1957	180.8	155.1	155.4	155.1	185.7		182.6	155.1	167.1
1958	95.7	77.9	82.9	77.9	79.8		129.7	80.5	102.6
1959	70.5	111.9	137.5	111.9	108.9		172.9	121.2	139.3
1960	106.9	74.9	70.3	74.9	121.9		115.3	144.9	80.4
1961	154.8	98.5	154.4	98.5	94.1		134.5	155.1	46.8
1962	191.2	121.3	86.1	121.3	93.1		115.3	155.1	102.1
1963	76.6	203.8	93.7	203.8	147.4		91.2	182.2	204.0
1964	121.6	134.6	128.1	134.6	188.9		168.1	134.7	114.6
1965	140.7	139.6	131.3	139.6	137.7		129.7	161.9	141.9
1966	83.9	83.0	88.0	83.0	131.9		91.2	131.3	84.2
1967	64.9	117.5	133.8	117.5	91.7		115.3	117.8	48.4
1968	160.4	174.5	105.9	174.5	193.0		124.9	144.9	187.9
1969	156.1	239.5	196.9	239.5	160.1		96.0	175.4	159.7
1970	106.7	112.3	82.5	112.3	115.0		67.2	100.8	98.8
1971	101.9	103.6	84.4	103.6	88.2		100.3	144.9	108.8
1972	308.0	238.6	220.4	238.6	203.8		177.7	155.1	311.2
1973	109.2	67.5	99.0	65.5	147.4		120.1	43.2	96.8
1974	154.5	189.9	196.6	199.9	160.8		172.9	141.5	156.4
1975	100.9	110.3	127.7	110.3	163.8		144.1	111.0	112.8
1976	204.1	176.5	195.3	176.5	167.9		168.3	141.5	205.5

KIRKUK PROVINCE

YEAR									
1950	116.8	154.5	100.4	126.2	132.8	129.7	167.3	108.4	105.2
1951	94.9	77.9	115.3	90.3	68.3	102.8	77.8	73.7	72.4
1952	74.8	111.6	124.8	116.0	146.3	134.2	149.4	142.6	117.8
1953	134.2	108.1	109.1	104.2	135.3	100.6	144.8	116.4	125.9
1954	230.2	177.3	222.0	215.2	213.7	192.5	194.7	225.0	248.3
1955	79.9	111.2	102.2	101.7	38.1	100.6	86.1	110.8	118.3
1956	112.3	104.2	120.0	108.7	177.5	109.5	160.3	176.6	172.2
1957	236.0	205.4	234.6	239.6	167.4	147.7	169.9	222.8	221.9
1958	81.6	69.7	94.1	72.3	126.0	136.5	111.3	95.3	88.0
1959	95.4	152.1	142.6	151.0	149.2	127.5	147.6	150.2	148.0
1960	87.2	65.5	104.3	76.1	97.4	136.5	110.4	94.3	79.5
1961	180.3	119.4	99.7	105.1	109.6	118.5	112.6	142.3	146.6
1962	135.2	141.3	92.6	113.6	125.6	105.1	129.1	130.1	130.3
1963	49.6	161.9	102.0	131.6	52.7	91.6	53.5	72.7	93.0
1964	67.3	117.0	117.1	114.4	144.6	147.7	159.3	86.3	84.2
1965	135.0	138.0	123.1	130.6	150.1	154.4	152.3	137.8	117.1
1966	111.0	80.0	110.9	88.8	98.2	118.5	114.8	89.3	65.0
1967	71.0	84.1	106.2	88.3	66.3	96.1	68.0	39.7	49.9
1968	184.3	178.6	117.6	151.1	189.3	138.7	161.0	159.1	151.0
1969	123.8	173.6	146.4	166.1	129.9	87.1	111.2	136.4	136.4
1970	79.7	127.7	149.8	141.1	83.9	89.4	95.5	96.5	115.4
1971	110.0	122.3	134.0	128.1	103.3	161.1	88.2	119.6	114.2
1972	280.5	175.7	167.0	180.1	199.4	163.4	185.6	219.0	199.9
1973	101.9	96.5	102.7	93.4	125.2	179.1	133.0	94.1	118.6
1974	167.9	153.1	193.1	182.9	161.0	143.2	167.7	176.3	177.9
1975	145.0	127.8	97.2	108.4	114.7	149.9	108.2	100.4	111.4
1976	206.4	157.4	163.0	166.8	135.8	129.7	132.0	196.1	183.4

1950	116.8	164.4	114.6	146.5	132.0	131.2	170.9	164.7	146.5
1951	94.9	70.2	108.8	94.4	64.0	104.2	75.8	141.6	94.4
1952	74.8	111.6	111.3	109.2	148.2	135.7	151.1	127.7	109.2
1953	134.2	107.3	118.8	118.5	132.0	102.0	144.4	145.9	119.5
1954	230.2	192.5	235.4	223.5	215.0	194.0	196.7	178.9	223.5
1955	79.9	111.1	94.8	91.0	78.9	102.0	83.2	113.5	91.0
1956	112.3	102.5	135.4	121.2	182.8	111.0	162.6	129.1	121.2
1957	236.0	227.0	239.9	249.4	173.6	149.1	173.2	242.4	249.4
1958	81.6	60.2	96.1	84.2	118.1	137.9	108.0	44.0	84.2
1959	95.4	161.5	141.8	166.0	146.3	128.9	149.0	153.2	166.0
1960	87.2	54.9	99.2	75.4	90.5	137.9	107.8	101.5	75.4
1961	180.3	121.3	123.7	121.6	103.2	119.9	111.2	131.8	121.6
1962	135.2	148.1	31.4	62.9	114.6	106.5	125.5	109.7	62.9
1963	49.6	173.6	116.6	130.8	51.4	93.0	51.2	228.9	130.8
1964	67.3	118.3	87.5	89.5	148.2	149.1	162.4	98.8	89.5
1965	135.0	144.2	146.5	146.4	151.6	155.8	154.0	142.8	146.4
1966	111.0	72.7	71.7	63.2	92.8	119.9	112.2	95.9	63.2
1967	71.0	77.8	43.6	46.8	72.2	97.5	69.2	122.4	46.8
1968	184.3	194.0	155.7	167.6	183.7	140.1	162.1	166.6	167.6
1969	123.8	188.0	136.3	164.3	128.6	88.5	109.7	165.3	164.3
1970	79.7	131.4	101.6	117.8	74.3	90.8	90.9	71.4	117.8
1971	110.0	142.9	165.8	120.9	106.7	162.6	88.3	145.4	120.9
1972	280.5	190.5	179.9	184.3	205.9	164.8	189.7	189.4	184.3
1973	101.9	93.0	113.7	107.1	122.8	180.5	132.7	87.8	107.1
1974	167.9	162.7	194.0	192.0	158.5	144.6	167.5	126.1	192.0
1975	145.0	131.5	110.4	126.2	112.4	151.4	106.8	105.4	126.2
1976	206.4	167.9	182.0	179.9	135.5	131.2	132.5	138.9	179.9

APPENDIX J, TABLE J.1
REGRESSION OF BARLEY YIELD ON TOTAL RAINFALL IN THE RAINFED AREA OF NORTHERN IRAQ(MM)

		PERIOD ONE 1949/50-1975/76						PERIOD TWO 1949/50-1957/58					
STATION	PROVINCE	FUNCTION[1]	NO. OF CASES	R	R^2	S.E.	F-VALUE	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1 SINJAR	NINEVEH	Y = 51.75 + 0.33TR (4.10)	27	.64	.40	68.11	16.78	Y =-10.38 + 0.47TR (2.50)	9	.69	.47	86.90	6.26
2 MOSUL	NINEVEH	Y = 6.08 + 0.47TR (3.80)	27	.61	.37	70.00	14.46	Y =-50.56 + 0.61TR (2.33)	9	.67	.45	88.99	5.65
3 TELAFAR	NINEVEH	Y = 36.08 + 0.47TR (3.84)	27	.61	.37	69.85	14.73	Y =-140.68+ 1.16TR (3.40)	9	.79	.62	73.42	11.55
4 AQRA	NINEVEH	Y = -8.37 + 0.21TR (3.93)	20	.68	.46	65.70	15.42	Y =-70.05 + 0.27TR (2.47)	6	.78	.60	81.01	6.10
5 SEPSANK	NINEVEH	Y =116.21 + 0.09TR (1.94)	20	.47	.17	80.32	3.77	Y =136.07 + 0.06TR (0.76)	9	.27	.08	114.92	0.58
6 DOHUK	NINEVEH	Y = 26.29 + 0.28TR (3.06)	20	.59	.34	73.33	9.38	Y =-160.92+ 0.64TR (2.86)	8	.76	.58	82.49	8.19
7 AMADIYA	NINEVEH	Y =120.20 + 0.09TR (1.52)	18	.36	.13	90.29	2.31	Y =-354.38+ 0.74TR (5.02)	8	.90	.81	55.66	25.17
8 ZAKHO	NINEVEH	Y =-124.47+ 0.47TR (3.96)	13	.77	.59	72.67	15.70	Y =-176.67+ 0.56TR (2.23)	7	.71	.50	97.81	4.98
9 KIRKUK	KIRKUK	Y =-10.92 + 0.52TR (3.81)	27	.61	.37	76.46	14.46	Y =-50.11 + 0.72TR (2.60)	9	.70	.49	99.96	6.75
10 HAWIJA	KIRKUK	Y = 13.82 + 0.68TR (3.69)	27	.59	.35	77.40	13.56	Y = 21.59 + 0.80TR (2.03)	9	.61	.37	111.10	4.13
11 IFTIKHAR	KIRKUK	Y = 81.58 + 0.43TR (2.27)	21	.46	.21	91.32	5.14	Y = 59.15 + 0.59TR (1.85)	9	.57	.33	114.96	3.42
12 TUZ-KHURMATU	KIRKUK	Y =110.04 + 0.37TR (2.54)	21	.50	.25	89.31	6.47	Y = 96.12 + 0.52TR (1.76)	7	.61	.38	119.62	3.11
13 SHAQLAWA	ARBIL	Y =125.16 + 0.42TR (1.32)	27	.26	.07	53.79	1.74	Y = 87.64 + 0.12TR (1.59)	9	.52	.27	62.14	2.52
14 ARBIL	ARBIL	Y =161.19 + 0.02TR (0.16)	23	.04	.00	62.75	0.03	Y = 99.20 + 0.25TR (1.32)	9	.45	.20	64.82	1.75
15 RAWNDUZ	ARBIL	Y = 90.65 + 0.09TR (2.15)	22	.43	.19	50.69	4.64	Y = 60.04 + 0.15TR (1.92)	9	.59	.35	59.64	3.69
16 SALAHUDDIN	ARBIL	Y =130.98 + 0.03TR (0.46)	21	.10	.01	54.79	0.20	Y =-151.32+ 0.53TR (6.30)	4	.98	.95	24.15	39.73
17 DOKAN	SULAIMANIYA	Y =158.58 + 0.04TR (0.59)	26	.12	.01	82.19	0.35	Y =193.12 + 0.43TR (0.31)	8	.13	.02	124.06	0.98
18 SULAIMANIYA	SULAIMANIYA	Y =179.70 + 0.01TR (0.15)	23	.03	.00	87.89	0.23	Y =111.54 + 0.18TR (0.86)	8	.33	.11	116.55	0.74
19 HALABJA	SULAIMANIYA	Y =170.80 + 0.02TR (0.14)	23	.03	.00	96.43	0.02	Y = 29.12 + 0.33TR (1.55)	9	.51	.26	103.96	2.41
20 BAKRAJO	SULAIMANIYA	Y =150.72 + 0.05TR (0.46)	20	.11	.01	92.72	0.21	Y =158.13 + 0.12TR (0.50)	6	.24	.06	141.07	0.25
21 PENJWIN	SULAIMANIYA	Y =116.44 + 0.08TR (1.10)	12	.32	.10	96.09	1.19	Y =104.41 + 0.09TR (0.86)	9	.31	.10	114.49	0.75
22 CHWARTA	SULAIMANIYA	Y = 55.01 + 0.20TR (1.93)	11	.54	.29	86.14	3.72	Y = 24.15 + 0.23TR (1.52)	7	.56	.32	113.22	2.31

		PERIOD THREE 1963/64-1975/76						PERIOD FOUR 949/50-1957/58 & 1963/64-1975/67					
STATION	PROVINCE	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1 SINJAR	NINEVEH	Y = 26.04 + 0.38TR (4.75)	13	.82	.67	47.68	22.59	Y = 12.99 + 0.42TR (5.02)	22	.75	.56	62.77	25.77
2 MOSUL	NINEVEH	Y =-46.49 + 0.59TR (4.61)	13	.81	.66	48.66	21.24	Y =-48.52 + 0.60TR (4.87)	22	.74	.54	63.33	23.67
3 TELAFAR	NINEVEH	Y =-11.70 + 0.54TR (6.48)	13	.89	.79	37.94	42.04	Y = -4.78 + 0.59TR (4.71)	22	.73	.53	64.38	22.14
4 AQRA	NINEVEH	Y =-17.56 + 0.23TR (3.83)	13	.76	.57	54.51	14.70	Y =-35.11 + 0.25TR (4.79)	19	.76	.57	59.91	22.91
5 SEPSANK	NINEVEH	Y = 86.07 + 0.10TR (2.00)	7	.67	.45	59.52	4. 5	Y =118.08 + 0.09TR (1.59)	16	.39	.15	89.43	0.13
6 DOHUK	NINEVEH	Y = 20.72 + 0.23TR (2.45)	7	.74	.55	53.79	6.01	Y = 4.36 + 0.30TR (2.64)	15	.59	.35	81.00	6.99
7 AMADIYA	NINEVEH	Y =144.66 + 0.07TR (0.99)	8	.37	.14	83.41	0.98	Y =111.90 + 0.11TR (1.64)	16	.40	.16	93.29	2.70
8 ZAKHO	NINEVEH	Y =-96.18 + 0.42TR (4.22)	6	.90	.81	44.62	17.77	Y =-127.47+ 0.47TR (3.96)	13	.77	.59	72.67	15.70
9 KIRKUK	KIRKUK	Y =-22.26 + 0.50TR (3.11)	13	.68	.47	58.68	9.65	Y =-32.14 + 0.58TR (3.77)	22	.64	.42	79.79	14.20
10 HAWIJA	KIRKUK	Y =-40.52 + 0.82TR (4.23)	13	.79	.62	49.63	17.88	Y = -4.07 + 0.77TR (3.65)	22	.63	.40	80.33	13.32
11 IFTIKHAR	KIRKUK	Y =221.36 - 0.28TR (0.49)	7	.21	.05	86.46	0.24	Y = 75.25 + 0.49TR (1.96)	16	.46	.22	102.59	3.99
12 TUZ-KHURMATU	KIRKUK	Y = 97.92 + 0.46TR (1.68)	10	.50	.25	77.62	2.75	Y = 90.97 + 0.52TR (3.04)	17	.62	.38	89.63	9.26
13 SHAQLAWA	ARBIL	Y =106.92 + 0.04TR (1.18)	13	.34	.11	51.50	1.39	Y =123.17 + 0.05TR (1.31)	22	.28	.08	61.75	1.71
14 ARBIL	ARBIL	Y =170.48 - 0.05TR (0.35)	13	.11	.01	54.35	0.12	Y =161.50 + 0.02TR (0.16)	22	.03	.00	64.29	0.02
15 RAWNDUZ	ARBIL	Y =103.80 + 0.07TR (1.81)	9	.59	.35	32.11	3.27	Y = 91.04 + 0.11TR (2.60)	17	.56	.31	47.71	6.72
16 SALAHUDDIN	ARBIL	Y =155.89 - 0.02TR (0.36)	12	.11	.01	47.86	0.13	Y =129.79 + 0.03TR (0.48)	16	.13	.02	59.62	0.23
17 DOKAN	SULAIMANIYA	Y =119.63 + 0.07TR (1.14)	13	.33	.11	45.61	1.30	Y =141.71 + 0.07TR (0.95)	21	.21	.05	82.32	0.90
18 SULAIMANIY	SULAIMANIYA	Y =144.55 - 0.03TR (0.42)	10	.15	.02	53.97	0.18	Y =144.59 + 0.08TR (0.73)	18	.18	.03	89.53	0.18
19 HALABJA	SULAIMANIYA	Y =105.37 + 0.04TR (0.52)	6	.29	.08	32.98	0.29	Y =113.85 + 0.12TR (0.83)	14	.23	.05	101.50	0.68
20 BAKRAJO	SULAIMANIYA	Y =135.05 + 0.03TR (0.39)	9	.14	.02	39.65	0.14	Y =110.14 + 0.11TR (0.99)	15	.27	.07	95.77	0.98
21 PENJWIN	SULAIMANIYA	NO SIGNIFICANT VAR IN THE FUNCTION						Y =104.41 + 0.09TR (0.86)	9	.31	.10	114.49	0.75
22 CHWARTA	SULAIMANIYA	NO SIGNIFICANT VAR IN THE FUNCTION						Y = 24.15 + 0.23TR (1.52)	7	.56	.32	113.22	2.31

WHERE
TR=TOTAL RAINFALL

VALUE IN BRACKETS IS THE T-VALUE

APPENDIX J, TABLE J.2
REGRESSION OF BARLEY YIELD ON MONTHLY RAINFALL(MM) IN THE RAINFED AREA OF NORTHERN IRAQ

	STATION	PROVINCE	PERIOD ONE 1949/50-1975/76 FUNCTION	NO. OF CASES	R	R²	S.E.	F-VALUE	PERIOD TWO 1949/50-1957/58 FUNCTION	NO. OF CASES	R	R²	S.E.	F-VALUE
1	SINJAR	NINEVEH	Y = 82.80 + 0.55R4 + 1.06R7 (2.25) (3.86)	27	.70	.49	64.29	11.46	Y = 87.25 + 1.91R7 (3.492)	9	.80	.64	72.38	12.12
2	MOSUL	NINEVEH	Y = 39.39 + 1.41R2 + 1.41R6 (3.00) (4.84)	27	.73	.53	61.92	13.28	Y = 22.53 + 2.09R6 (4.05)	9	.84	.70	65.45	16.39
3	TELAFAR	NINEVEH	Y = 59.07 + 1.49R2 + 1.41R6 (2.85) (3.98)	27	.66	.44	67.53	9.25	Y =120.74 + 1.89R6 - 2.88R8 (6.38) (3.63)	9	.94	.89	42.91	24.21
4	AQRA	NINEVEH	Y = 76.53 + 0.67R6 (3.27)	20	.61	.37	70.90	10.69	Y = 22.67 + 1.27R4 (5.92)	6	.95	.90	41.19	35.06
5	SERSANK	NINEVEH	Y =125.09 + 0.38R6 (2.37)	20	.49	.24	77.10	5.63	NO SIGNIFICANT VARS IN THE FUNCTION					
6	DOHUK	NINEVEH	Y =103.98 + 1.23R7 (2.46)	20	.50	.25	79.20	6.08	Y =-42.03 + 5.45R1 + 2.27R6 - 0.93R8 (7.76) (23.12) (7.71)	9	.99	.99	12.37	209.1
7	AMADIYA	NINEVEH	Y =116.36 + 0.55R6 (2.85)	18	.58	.34	78.62	8.15	Y =-147.75+ 1.32R6 + 1.43R7 (4.56) (2.97)	9	.94	.89	48.01	18.44
8	ZAKHO	NINEVEH	Y = -3.78 + 1.84R6 (5.26)	13	.85	.72	60.38	27.38	Y = 56.82 - 0.61R4 + 1.91R6 - 0.63R8 (6.21) (42.69) (14.06)	7	.99	.99	6.92	663.9
9	KIRKUK	KIRKUK	Y = 87.18 + 0.90R2 + 0.94R6 (2.04) (3.56)	27	.69	.36	79.25	6.87	Y = 21.03 + 1.90R2 + 1.90R6 (2.15) (5.20)	9	.91	.94	61.24	15.32
10	HAWIJA	KIRKUK	Y =120.20 + 1.62R6 (4.24)	27	.65	.42	73.33	17.96	Y =133.69 + 1.74R6 (2.64)	9	.71	.50	99.12	6.99
11	IFTIKHAR	KIRKUK	Y =124.78 + 1.48R7 (2.96)	21	.55	.30	86.07	9.17	Y = 99.33 + 3.09R7 (4.35)	9	.85	.73	72.90	18.92
12	TUZ-KHURMATU	KIRKUK	Y =157.25 - 1.05R4 + 2.09R7 (1.89) (3.91)	21	.67	.45	78.90	7.31	Y =107.38 + 2.70R7 (3.38)	7	.83	.70	84.10	11.40
13	SHAQLAWA	ARBIL	Y =122.99 + 0.21R5 (2.17)	27	.40	.16	55.78	4.69	Y =108.21 + 0.61R6 (2.21)	9	.64	.41	55.62	4.88
14	ARBIL	ARBIL	Y =189.23 - 3.61R1 (1.98)	23	.40	.16	57.65	3.91	Y =105.31 + 1.31R6 (2.63)	9	.71	.50	51.36	6.94
15	RAWNDUZ	ARBIL	Y =134.55 + 0.33R3 (1.92)	22	.39	.16	51.70	3.68	NO SIGNIFICANT VARS IN THE FUNCTION					
16	SALAHUDDIN	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION						NO SIGNIFICANT VARS IN THE FUNCTION					
17	DOKAN	SULAIMANIYA	Y =211.34 - 3.40R1 (1.85)	26	.35	.13	77.43	3.43	NO SIGNIFICANT VARS IN THE FUNCTION					
18	SULAIMANIYA	SULAIMANIYA	Y =183.19 + 0.79R2 - 0.81R4 + 0.33R6 (3.14) (3.10) (2.07)	23	.69	.48	66.51	5.91	Y =152.58 - 1.96R1 + 1.70R2 (3.74) (5.66)	8	.93	.87	48.29	17.12
19	HALIBJA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =116.10 + 1.78R2 (3.85)	9	.82	.68	69.24	14.81
20	BAKRAJO	SULAIMANIYA	Y =182.32 - 2.59R1 + 0.66R2 - 0.68R4 (2.26) (2.75) (2.51) 046+ 0.60R6 - 0.53R8 (2.92) (1.98)	20	.83	.69	58.91	6.23	NO SIGNIFICANT VARS IN THE FUNCTION					
21	PENJWIN	SULAIMANIYA	Y =152.94 + 0.51R2 (3.96)	12	.78	.61	63.43	15.43	Y =140.71 - 0.55R2 (3.48)	9	.80	.63	72.85	12.14
22	CHWARTA	SULAIMANIYA	Y = 74.37 + 1.03R2 + 0.38R6 (4.43) (2.41)	11	.87	.76	53.30	12.61	Y =115.35 + 1.56R2 (6.37)	7	.94	.89	45.37	40.52

	STATION	PROVINCE	PERIOD THREE 1963/64-1975/76 FUNCTION	NO. OF CASES	R	R²	S.E.	F-VALUE	PERIOD FOUR 1949/50-1957/58 & 1963/64-1975/67 FUNCTION	NO. OF CASES	R	R²	S.E.	F-VALUE
1	SINJAR	NINEVEH	Y = 58.39 + 0.70R3 + 0.32R4 + 0.81R7 (2.85) (2.04) (2.91)	13	.94	.88	32.60	20.95	Y = 55.34 + 0.51R4 + 1.56R7 (2.46) (5.80)	22	.84	.70	53.19	21.94
2	MOSUL	NINEVEH	Y = 15.98 + 0.80R3 + 0.81R6 + 1.04R7 (1.96) (2.64) (3.11)	13	.88	.77	43.79	10.27	Y = 13.02 + 0.86R2 + 1.33R6 + 0.81R7 (1.74) (4.76) (2.41)	22	.90	.73	51.99	15.95
3	TELAFAR	NINEVEH	Y = 66.29 + 1.42R3 + 0.62R5 (4.23) (2.02)	13	.84	.71	46.97	12.30	Y = -0.44 + 1.76R2 + 0.67R5 + 1.60R6 (3.32) (2.05) (4.72)	22	.79	.63	60.52	10.19
4	AQRA	NINEVEH	Y = 77.87 + 0.46R3 + 0.99R8 (3.39) (2.27)	13	.80	.63	52.99	8.60	Y = 64.71 + 0.55R3 + 1.09R8 (3.46) (2.17)	19	.72	.52	65.58	8.65
5	SERSANK	NINEVEH	Y =123.84 + 0.51R4 (3.63)	7	.85	.72	41.93	13.14	Y =114.88 + 0.42R6 (2.10)	16	.49	.24	84.69	4.42
6	DOHUK	NINEVEH	Y = 42.49 + 0.86R3 + 0.19R6 (7.62) (3.66)	7	.97	.94	21.42	32.73	Y =103.78 + 1.25R7 (2.06)	15	.50	.25	87.18	4.25
7	AMADIYA	NINEVEH	NO SIGNIFICANT VARS IN THE FUNCTION						Y =117.40 + 0.55R6 (2.69)	16	.59	.34	82.73	7.23
8	ZAKHO	NINEVEH	Y =-157.54 + 3.51R6 (8.26)	6	.97	.95	24.50	68.25	Y = -3.78 + 1.84R6 (5.26)	13	.85	.72	60.38	27.67
9	KIRKUK	KIRKUK	Y = 90.36 + 0.59R6 + 3.00R8 (2.52) (3.53)	13	.77	.60	53.34	7.50	Y =127.44 + 0.84R6 (2.77)	22	.53	.28	89.74	7.65
10	HAWIJA	KIRKUK	Y = 53.64 + 0.75R4 + 1.09R6 + 4.64R8 (2.82) (3.05) (4.69)	13	.93	.86	33.50	19.13	Y =112.59 + 1.73R6 (4.05)	22	.67	.45	74.35	16.39
11	IFTIKHAR	KIRKUK	Y =123.41 + 6.27R8 (4.80)	7	.91	.92	37.39	23.02	Y =120.85 + 1.93R7 (3.00)	16	.63	.39	90.45	9.97
12	TUZ-KHURMATU	KIRKUK	Y =162.33 - 5.26R2 + 15.03R8 (2.10) (3.33)	10	.79	.63	58.69	5.90	Y =138.54 + 1.94R7 (3.32)	17	.65	.42	86.50	11.05
13	SHAQLAWA	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION						Y =125.29 + 0.21R5 ([illegible])	22	.41	.17	58.61	4.09
14	ARBIL	ARBIL	Y =171.58 - 3.77R1 (2.37)	13	.58	.34	44.49	5.60	Y =189.47 - 3.61R1 (1.93)	22	.40	.16	59.10	3.73
15	RAWNDUZ	ARBIL	Y =126.58 + 0.33R3 (3.16)	8	.79	.63	24.44	10.00	Y =133.01 + 0.40R3 (1.93)	17	.45	.20	51.45	3.72
16	SALAHUDDIN	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION						Y =127.44 + 0.46R8 (2.11)	16	.49	.24	52.34	4.46
17	DOKAN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =224.92 - 3.86R1 (2.04)	21	.42	.18	76.28	4.17
18	SULAIMANIYA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =145.18 - 1.81R1 + 1.28R2 (3.03) (4.08)	18	.75	.56	62.40	9.52
19	HALABJA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 83.84 + 1.36R7 (2.45)	14	.58	.33	95.20	6.00
20	BAKRAJO	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 98.45 + 1.13R2 (2.96)	15	.63	.40	76.82	8.74
21	PENJWIN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =140.71 + 0.55R2 (3.48)	9	.80	.63	72.85	12.14
22	CHWARJA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =115.35 + 1.56R2 (6.37)	7	.94	.89	45.37	40.52

R1= OCTOBER RAINFALL   VALUE IN BRACKETS IS THE T-VALUE
R1= OCTOBER RAINFALL
R2= NOVEMBER RAINFALL
R3= DECEMBER RAINFALL
R4= JANUARY RAINFALL
R5= FEBRUARY RAINFALL
R6= MARCH RAINFALL
R7= APRIL RAINFALL
R8= MAY RAINFALL

APPENDIX J, TABLE J.3
REGRESSION OF BARLEY YIELD ON MONTHLY AND TOTAL RAINFALL(MM) IN THE RAINFED AREA OF NORTHERN IRAQ

	STATION	PROVINCE	PERIOD ONE 1949/50-1975/76 FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD TWO 1949/50-1957/58 FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1	SINJAR	NINEVEH	Y = 59.86 + 0.61R7 (1.82) - 0.68R8 (2.67) + 0.28TR (2.85)	27	.77	.59	58.60	11.52	Y = 87.25 + 1.91R7 (3.48)	9	.90	.63	72.38	12.12
2	MOSUL	NINEVEH	Y = 5.95 - 0.76R5 (2.15) - 0.98R8 (2.57) + 0.66TR (5.18)	27	.74	.55	61.40	9.47	Y = 22.53 + 2.09R6 (4.05)	9	.84	.70	65.45	16.39
3	TELAFAR	NINEVEH	Y = 19.80 - 1.20R8 (2.78) + 0.60TR (5.08)	27	.73	.52	61.98	13.23	Y =120.74 + 1.89R6 (6.38) - 2.88R8 (3.63)	9	.94	.89	42.91	24.21
4	AQRA	NINEVEH	Y = -8.37 + 0.21TR (3.93)	20	.68	.46	65.71	15.42	Y = 22.97 + 1.27R4 (5.92)	6	.95	.90	41.19	35.06
5	SERSANK	NINEVEH	Y =125.09 + 0.38R8 (2.37)	20	.49	.24	77.09	5.63	NO SIGNIFICANT VARS IN THE FUNCTION					
6	DOHUK	NINEVEH	Y = 26.29 + 0.28TR (3.06)	20	.59	.34	73.33	9.39	Y =-42.03 + 5.45R1 (7.76) + 2.27R6 (23.12) - 0.93R8 (7.71)	8	.99	.99	12.37	209.1
7	AMADIYA	NINEVEH	Y =116.36 + 0.55R6 (2.85)	18	.58	.34	78.62	9.15	Y =-354.38+ 0.74TR (5.02)	8	.90	.81	55.66	25.17
8	ZAKHO	NINEVEH	Y = -3.38 + 1.84R6 (5.26)	13	.85	.72	60.38	27.67	Y = 56.82 - 0.61R4 (6.21) + 1.91R6 (42.69) - 0.63R8 (14.06)	7	.99	.99	6.92	663.9
9	KIRKUK	KIRKUK	Y =-10.92 + 0.52TR (3.81)	27	.61	.37	76.46	14.52	Y = 21.03 + 1.90R2 (2.15) + 1.90R6 (5.20)	9	.91	.84	61.24	15.32
10	HAWIJA	KIRKUK	Y =120.20 + 1.62R6 (4.24)	27	.65	.42	73.33	17.96	Y =133.69 + 1.74R6 (2.64)	9	.71	.50	99.12	6.99
11	IFTIKHAR	KIRKUK	Y =124.78 + 1.43R7 (2.96)	21	.55	.30	86.07	8.17	Y = 89.33 + 3.09R7 (4.35)	9	.85	.73	72.80	18.92
12	TUZ-KHURMATU	KIRKUK	Y =157.25 - 1.05R4 (1.89) + 2.09R7 (3.81)	21	.67	.45	78.90	7.31	Y =107.38 + 2.70R7 (3.38)	7	.83	.70	84.10	11.40
13	SHAQLAWA	ARBIL	Y =122.99 + 0.21R5 (2.17)	27	.40	.16	55.73	4.69	Y =108.21 + 0.61R6 (2.21)	9	.64	.41	55.62	4.88
14	ARBIL	ARBIL	Y =189.23 - 3.61R1 (1.98)	23	.40	.16	57.65	3.91	Y =105.31 + 1.31R6 (2.63)	9	.71	.50	51.36	6.94
15	RAWNDUZ	ARBIL	Y = 99.59 - 0.38R7 (1.94) + 0.14TR (2.97)	22	.57	.32	47.51	4.52	Y = 60.04 + 0.15TR (1.92)	9	.59	.35	58.64	3.69
16	SALAHUDDIN	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION						Y =-151.32+ 0.53TR (6.30)	4	.98	.95	24.15	39.73
17	DOKAN	SULAIMANIYA	Y =211.34 - 3.40R1 (1.83)	26	.35	.13	77.43	3.43	NO SIGNIFICANT VARS IN THE FUNCTION					
18	SULAIMANIYA	SULAIMANIYA	Y =183.19 + 0.79R2 (3.14) - 0.81R4 (3.10) + 0.33R6 (2.07)	23	.69	.49	66.51	5.91	Y =152.58 - 1.96R1 (3.74) + 1.70R2 (5.66)	8	.93	.87	48.29	17.12
19	HALABJA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =116.10 + 1.78R2 (3.85)	9	.82	.69	68.24	14.81
20	BAKRAJO	SULAIMANIYA	Y =182.32 - 2.59R1 (2.26) + 0.66R2 (2.75) - 0.68R4 (2.51) 0230 0.60R6 (2.92) - 0.53R8 (1.98)	20	.83	.69	58.91	6.23	NO SIGNIFICANT VARS IN THE FUNCTION					
21	PENJWIN	SULAIMANIYA	Y =152.94 + 0.51R2 (3.96)	12	.78	.61	63.43	15.65	Y =140.71 + 0.55R2 (3.48)	9	.80	.63	72.85	12.14
22	CHWARTA	SULAIMANIYA	Y = 74.37 + 1.03R2 (24.43) + 0.38R6 (2.41)	11	.87	.76	53.30	12.61	Y =115.35 + 1.56R2 (6.37)	7	.94	.89	45.37	40.52

	STATION	PROVINCE	PERIOD THREE 1963/64-1975/76 FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD FOUR 1949/50-1957/58 & 1963/64-1975/67 FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE
1	SINJAR	NINEVEH	Y = 58.39 + 0.70R3 (2.85) + 0.32R4 (2.04) + 0.81R7 (2.91)	13	.94	.88	32.59	20.95	Y = 55.34 + 0.51R4 (2.46) + 1.56R7 (5.80)	22	.84	.70	53.19	21.94
2	MOSUL	NINEVEH	Y =-65.30 + 0.83R7 (2.81) + 0.52TR (4.99)	13	.90	.81	38.13	21.26	Y = 13.02 + 0.86R2 (1.74) + 1.33R6 (4.76) + 0.81R7 (2.41)	22	.85	.73	51.99	15.94
3	TELAFAR	NINEVEH	Y =-11.70 + 0.54TR (6.49)	13	.89	.79	37.94	42.04	Y = -8.59 + 0.72R6 (1.92) + 0.46TR (3.41)	22	.78	.60	61.00	14.39
4	AQRA	NINEVEH	Y =-17.56 + 0.23TR (3.83)	13	.76	.57	54.51	14.70	Y =-35.11 + 0.25TR (4.79)	19	.76	.57	59.91	22.91
5	SERSANK	NINEVEH	Y =123.84 + 0.51R4 (3.63)	7	.85	.72	41.92	13.14	Y =114.83 + 0.42R6 (2.10)	16	.49	.24	84.69	4.42
6	DOHUK	NINEVEH	Y = 42.49 + 0.86R3 (7.62) + 0.19R6 (3.66)	7	.97	.94	21.42	32.73	Y = 4.36 + 0.30TR (2.64)	15	.59	.35	81.00	6.98
7	AMADIYA	NINEVEH	NO SIGNIFICANT VARS IN THE FUNCTION						Y =117.40 + 0.55R6 (2.69)	16	.58	.34	82.73	7.23
8	ZAKHO	NINEVEH	Y =-157.54+ 3.51R6 (8.26)	6	.97	.94	24.50	68.25	Y = -3.78 + 1.84R6 (5.26)	13	.85	.72	60.38	27.67
9	KIRKUK	KIRKUK	Y = -7.10 + 1.60R8 (1.83) + 0.40TR (2.53)	13	.77	.60	53.30	7.52	Y =-32.14 + 0.58TR (3.77)	22	.64	.42	79.79	14.20
10	HAWIJA	KIRKUK	Y =-40.52 + 0.82TR (4.23)	13	.79	.62	49.63	17.88	Y =112.59 + 1.73R6 (4.05)	22	.67	.45	77.35	16.39
11	IFTIKHAR	KIRKUK	Y =123.41 + 6.27R8 (4.80)	7	.91	.82	37.39	23.02	Y =120.85 + 1.93R7 (3.00)	16	.63	.39	90.45	9.97
12	TUZ-KHURMATU	KIRKUK	Y =162.33 - 5.26R8 (2.10) + 15.03R8 (3.38)	10	.79	.63	58.69	5.90	Y =138.54 + 1.94R7 (3.32)	17	.65	.42	86.50	11.05
13	SHAQLAWA	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION						Y =125.29 + 0.21R5 (2.02)	22	.41	.17	58.61	4.09
14	ARBIL	ARBIL	Y =171.58 - 3.78R1 (2.37)	13	.58	.34	44.50	5.60	Y =189.47 - 3.61R1 (1.93)	22	.40	.16	59.10	3.73
15	RAWNDUZ	ARBIL	Y =126.58 + 0.33R3 (3.16)	8	.79	.63	24.44	10.00	Y = 91.04 + 0.11TR (2.60)	17	.56	.31	47.71	6.77
16	SALAHUDDIN	ARBIL	NO SIGNIFICANT VARS IN THE FUNCTION						Y =127.44 + 0.46R8 (2.11)	16	.49	.24	52.34	4.46
17	DOKAN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =224.92 - 3.86R1 (2.04)	21	.42	.18	76.28	4.17
18	SULAIMANIYA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =145.19 - 1.81R1 (3.03) + 1.28R2 (4.08)	18	.75	.56	62.40	9.52
19	HALABJA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 83.94 + 1.36R7 (2.45)	14	.58	.33	85.20	6.00
20	BAKRAJO	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y = 98.45 + 1.11R2 (2.96)	15	.63	.40	76.82	9.74
21	PENJWIN	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =140.71 + 0.55R2 (3.49)	9	.80	.63	72.85	12.14
22	CHWARTA	SULAIMANIYA	NO SIGNIFICANT VARS IN THE FUNCTION						Y =115.35 + 1.56R2 (6.37)	7	.94	.89	45.37	40.52

VALUE IN BRACKETS IS THE T-VALUE

TR= TOTAL RAINFALL
R1= OCTOBER RAINFALL
R1= OCTOBER RAINFALL
R2= NOVEMBER RAINFALL
R3= DECEMBER RAINFALL
R4= JANUARY RAINFALL
R5= FEBRUARY RAINFALL
R6= MARCH RAINFALL
R7= APRIL RAINFALL
R8= MAY RAINFALL

APPENDIX J, TABLE J.4
REGRESION OF BARLEY YIELD ON MONTHLY MINIMUM, MAXIMUM, MEAN AND SEASONAL TEMPERATURE IN THE RAINFED AREA OF NORTHERN IRAQ

MOSUL STATION NINEVEH PROVINCE

	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
MAXIMUM TEMPERATURE							
	Y =1167.6 - 21.62MAT2 - 12.94MAT6 - 10.03MAT7 (2.72) (1.84) (2.13)	27	.62	.39	71.80	4.37	1
	Y =2514.2 + 52.12MAT4 + 14.42MAT8 -156.44SMAT (8.56) (2.36) (11.38)	9	.98	.97	25.97	47.53	2
	Y =1203.7 - 48.01SMAT (1.82)	13	.48	.23	73.02	3.32	3
	Y =1369.9 - 17.24MAT2 - 23.38MAT6 - 9.03MAT7 (2.09) (3.46) (2.63)	22	.75	.56	66.21	7.53	4
MINIMUM TEMPERATURE							
	Y = 510.9 - 20.91MIT5 (2.20)	27	.40	.16	80.62	4.83	1
	Y = 338.0 + 66.71MIT1 -138.33MIT2 (2.19) (3.69)	9	.89	.74	65.89	8.54	2
	NO SIGNIFICANT VARS IN THE FUNCTION						3
	Y = 515.1 - 21.1MIT8 (2.09)	22	.42	.19	85.53	4.33	4
MEAN TEMPERATURE							
	Y = 602.5 - 28.78MT2 (2.34)	27	42	.19	79.73	5.49	1
	Y =1532.2 - 94.89MT2 (4.58)	9	87	.75	59.86	20.96	2
	NO SIGNIFICANT VARS IN THE FUNCTION						3
	Y =1529.3 + 27.88MT4 - 105.88SMT (2.17) (3.37)	22	.61	.38	76.36	5.75	4

KIRKUK STATION KIRKUK PROVINCE

	FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
MAXIMUM TEMPERATURE							
	Y =1553.7 - 28.61MAT2 - 15.16MAT6 - 16.19MAT7 (3.95) (1.94) (2.53)	27	.71	.51	70.50	7.83	1
	Y =2163.1 - 48.95MAT2 + 23.97MAT3 - 46.91MAT7 (5.61) (3.46) (8.29)	9	.98	.96	31.43	44.60	2
	NO SIGNIFICANT VARS IN THE FUNCTION						3
	Y =1311.4 - 29.22MAT2 - 17.71MAT7 (3.12) (2.39)	22	.66	.44	80.42	7.33	4
MINIMUM TEMPERATURE							
	Y = 482.9 - 26.45MIT2 (1.88)	27	.35	.12	89.96	3.55	1
	Y = 1380.3 -106.07MIT2 (3.60)	9	.81	.65	85.03	12.93	2
	NO SIGNIFICANT VARS IN THE FUNCTION						3
	Y = 519.8 - 29.43MIT2 (1.75)	22	.36	.13	97.15	3.07	4
MEAN TEMPERATURE							
	Y =1063.3 - 30.55MT2 - 18.10MT7 (2.91) (1.89)	27	.57	.32	80.84	5.68	1
	Y =2168.0 - 51.47MT2 - 54.64MT7 (2.68) (3.19)	9	.93	.86	57.35	17.89	2
	NO SIGNIFICANT VARS IN THE FUNCTION						3
	Y = 764.7 - 33.64MT2 (2.49)	22	.49	.24	91.15	6.20	4

MAT1= MAXIMUM OCTOBER TEMPERATURE
MAT2= MAXIMUM NOVEMBER TEMPERATURE
MAT3= MAXIMUM DECEMBER TEMPERATURE
MAT4= MAXIMUM JANUARY TEMPERATURE
MAT5= MAXIMUM FEBRUARY TEMPERATURE
MAT6= MAXIMUM MARCH TEMPERATURE
MAT7= MAXIMUM APRIL TEMPERATURE
MAT8= MAXIMUM MAY TEMPERATURE
SMAT= SEASONAL MAXIMUM TEMPERATURE

MIT1= MINIMUM OCTOBER TEMPERATURE
MIT2= MINIMUM NOVEMBER TEMPERATURE
MIT3= MINIMUM DECEMBER TEMPERATURE
MIT4= MINIMUM JANUARY TEMPERATURE
MIT5= MINIMUM FEBRUARY TEMPERATURE
MIT6= MINIMUM MARCH TEMPERATURE
MIT7= MINIMUM APRIL TEMPERATURE
MIT8= MINIMUM MAY TEMPERATURE
SMIT= SEASONAL MINIMUM TEMPERATURE

MT1= MEAN OCTOBER TEMPERATURE
MT2= MEAN NOVEMBER TEMPERATURE
MT3= MEAN DECEMBER TEMPERATURE
MT4= MEAN JANUARY TEMPERATURE
MT5= MEAN FEBRUARY TEMPERATURE
MT6= MEAN MARCH TEMPERATURE
MT7= MEAN APRIL TEMPERATURE
MT8= MEAN MAY TEMPERATURE
SMT= SEASONAL MEAN TEMPERATURE

VALUE IN BRACKETS IS THE T-VALUE

APPENDIX J, TABLE J.5
REGRESSION OF BARLEY YIELD ON MONTHLY RELATIVE HUMIDITY IN THE RAINFED AREA OF NORTHERN IRAQ

MOSUL STATION NINEVEH PROVINCE

FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = -208.8 + 6.30RH7 (4.52)	27	.67	.45	65.30	20.47	1
Y =-2739.8 + 20.17RH4 + 17.92RH6 (2.37) (5.37)	9	.92	.34	52.20	15.32	2
Y = -64.8 + 5.72RH8 (3.19)	13	.69	.48	60.00	10.18	3
Y = -248.7 + 7.06RH7 (4.83)	22	.73	.54	64.12	23.29	4

KIRKUK STATION KIRKUK PROVINCE

FUNCTION	NO. OF CASES	R	R^2	S.E.	F-VALUE	PERIOD
Y = -428.1 + 3.25RH3 + 7.75RH7 (1.73) (4.78)	27	.71	.51	68.92	12.39	1
Y = 258.7 - 16.66RH6 + 19.47RH7 (2.35) (4.20)	9	.91	.83	63.00	14.31	2
Y = -196.3 - 3.77RH1 + 5.46RH6 + 5.48RH8 (2.27) (3.15) (3.41)	13	.87	.75	44.42	9.02	3
Y = -466.1 + 3.14RH4 + 8.62RH7 (1.81) (5.08)	22	.76	.58	68.99	13.37	4

RH1= OCTOBER RELATIVE HUMIDITY
RH2= NOVEMBER RELATIVE HUMIDITY
RH3= DECEMBER RELATIVE HUMIDITY
RH4= JANUARY RELATIVE HUMIDITY
RH5= FEBRUARY RELATIVE HUMIDITY
RH6= MARCH RELATIVE HUMIDITY
RH7= APRIL RELATIVE HUMIDITY
RH8= MAY RELATIVE HUMIDITY

VALUE IN BRACKETS IS THE T-VALUE

APPENDIX J TABLE J.6
ACTUAL AND FORECASTED BARLEY YIELDS(KG./DONUM) IN NINEVEH AN KIRKUK PROVINCES

NINEVEH PROVINCE

PERIOD 1949/50-1975/76

YEAR	ACTUAL YIELD	TOTAL RAINFALL	MONTHLY RAINFALL	MONTHLY & TOTAL RAINFALL	MONTHLY MAX. TEMPERATURE	MONTHLY MIN. TEMPERATURE	MONTHLY MEAN TEMPERATURE	RELATIVE HUMIDITY	SELECTED VARIABLES
		FORECASTED YIELD							
1950	127.8	191.5	194.2	161.9	174.1	197.2	202.4	175.6	180.0
1951	58.1	126.4	114.6	88.1	65.5	201.4	142.0	150.4	54.1
1952	175.9	159.5	136.8	148.5	95.0	228.6	199.5	175.6	196.2
1953	311.7	195.0	188.9	207.6	245.1	243.2	205.3	257.5	211.4
1954	358.6	229.1	306.3	267.9	281.7	234.8	242.7	276.4	357.0
1955	59.4	154.9	121.3	157.7	117.8	195.1	170.7	150.4	113.6
1956	234.4	162.6	178.2	181.2	224.0	268.3	193.8	219.7	215.5
1957	310.5	212.7	278.2	201.7	199.5	207.7	228.3	219.7	240.7
1958	140.8	127.1	159.6	136.7	147.7	167.9	193.8	81.1	109.7
1959	117.9	164.7	209.5	112.8	238.8	197.2	211.0	156.7	160.0
1960	172.9	123.8	141.7	123.5	186.1	178.4	188.0	200.8	171.8
1961	202.7	149.9	209.9	146.9	217.5	186.7	173.6	219.7	200.4
1962	280.9	175.2	153.1	195.0	201.7	195.1	225.4	219.7	257.2
1963	143.9	266.6	122.2	141.3	168.0	190.9	150.6	270.1	204.8
1964	152.0	189.9	163.8	212.2	207.8	213.9	182.2	181.9	205.5
1965	190.9	195.4	172.6	221.6	196.1	190.9	182.2	232.3	229.1
1966	159.7	132.7	135.8	135.6	175.7	161.6	213.9	175.6	156.6
1967	109.7	170.9	190.8	165.5	113.6	144.9	81.5	150.4	58.7
1968	187.9	234.2	183.9	248.2	230.8	136.5	182.2	200.8	246.9
1969	326.9	306.2	320.0	362.2	221.8	155.4	165.0	257.5	257.9
1970	116.5	165.2	161.0	180.9	144.9	159.5	193.8	118.9	107.4
1971	138.9	155.6	160.3	166.4	141.6	109.4	118.9	200.8	178.7
1972	333.4	305.2	193.2	285.8	203.2	201.4	170.7	219.7	272.5
1973	115.6	115.6	156.5	121.1	209.7	149.1	193.8	11.8	50.9
1974	191.6	251.2	277.7	272.3	298.5	180.5	259.9	194.5	226.3
1975	80.5	163.0	154.9	158.9	146.1	157.5	170.7	137.8	149.9
1976	251.1	236.4	275.1	243.8	195.7	197.2	205.2	194.5	237.5

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PERIOD 1949/50-191957/58 AND 1963/64-1975/76
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YEAR	ACTUAL YIELD	TOTAL RAINFALL	MONTHLY RAINFALL	MONTHLE & TOTAL RAINFALL	MONTHLY MAX. TEMPERATURE	MONTHLY MIN. TEMPERATURE	MONTHLY MEAN TEMPERATURE	RELATIVE HUMIDITY	SELECTED VARIABLES
		FORECASTED YIELD							
1950	127.8	190.2	183.1	213.0	190.7	198.6	207.6	181.7	149.7
1951	58.1	108.6	84.4	103.8	43.0	202.9	153.6	153.5	80.9
1952	175.9	150.1	175.8	137.9	141.3	230.3	184.8	181.7	221.2
1953	311.7	182.1	197.4	197.1	317.2	245.1	242.8	273.4	203.4
1954	358.6	237.4	333.0	286.3	269.0	236.6	278.4	294.6	317.2
1955	59.4	144.3	121.5	114.7	94.0	196.5	94.0	153.5	65.5
1956	234.4	153.9	151.4	159.1	256.5	270.4	222.7	231.1	253.0
1957	310.5	216.8	261.1	268.4	219.7	209.2	262.2	231.1	279.9
1958	140.8	109.4	120.1	91.0	107.4	169.1	209.9	75.9	124.3
1959	117.9	156.6	201.5	170.4	333.2	198.6	308.0	160.6	210.6
1960	172.9	105.2	101.2	115.8	197.9	179.7	189.3	209.9	211.9
1961	202.7	138.1	215.9	114.4	240.4	185.1	189.8	231.1	128.1
1962	280.9	169.8	119.7	142.3	138.7	196.5	169.8	231.1	204.8
1963	143.9	284.5	109.1	231.3	205.7	192.3	186.5	287.6	245.1
1964	152.0	138.3	166.7	190.0	207.0	215.5	144.0	188.8	154.7
1965	190.9	195.2	173.9	188.5	172.5	192.3	187.6	245.2	205.2
1966	159.7	116.5	113.3	118.8	170.8	162.8	200.5	181.7	160.7
1967	109.7	164.5	188.3	183.5	163.6	145.9	161.4	153.5	122.3
1968	187.9	243.8	156.3	214.6	233.8	137.5	132.4	209.9	201.5
1969	326.8	334.2	316.2	295.2	224.8	156.5	135.8	273.4	340.5
1970	116.5	157.2	122.2	146.6	115.5	160.7	80.6	118.2	124.1
1971	138.9	145.2	124.2	148.4	116.5	110.0	151.9	209.9	151.6
1972	333.4	333.0	260.6	296.6	234.5	202.9	234.9	231.1	320.6
1973	115.6	94.9	133.0	81.3	200.9	150.1	121.8	-1.7	47.7
1974	191.6	265.2	297.6	301.2	297.7	181.8	255.0	202.9	237.1
1975	80.5	154.5	158.6	132.6	149.2	158.6	208.2	139.4	103.2
1976	251.1	246.6	292.9	263.9	206.5	198.6	261.7	202.9	267.7

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KIRKUK PROVINCE

YEAR	ACTUAL YIELD	TOTAL RAINFALL	MONTHLY RAINFALL	MONTHLY & TOTAL RAINFALL	MONTHLY MAX. TEMPERATURE	MONTHLY MIN. TEMPERATURE	MONTHLY MEAN TEMPERATURE	RELATIVE HUMIDITY	SELECTED VARIABLES
1950	148.5	225.8	141.6	141.6	166.4	186.7	167.4	164.8	180.4
1951	109.0	111.2	165.7	165.7	61.1	147.0	113.0	146.5	144.3
1952	93.7	161.6	180.9	180.9	189.9	194.6	181.4	162.3	176.3
1953	340.6	156.3	155.6	155.6	274.6	221.1	228.2	235.7	268.9
1954	494.5	260.0	337.4	337.4	333.5	226.4	298.1	305.4	386.3
1955	150.8	161.0	144.5	144.5	135.5	165.5	139.9	170.8	142.1
1956	216.5	150.5	173.1	173.1	242.4	194.6	210.4	251.5	240.3
1957	295.3	302.0	357.6	357.6	228.2	218.4	221.3	289.9	299.6
1958	124.8	99.0	131.5	131.5	135.4	184.0	164.7	46.1	76.7
1959	179.2	222.3	209.5	209.5	192.1	181.4	162.7	187.5	199.2
1960	104.0	92.6	147.9	147.9	186.2	202.5	191.1	109.5	139.3
1961	216.2	173.3	140.4	140.4	223.8	165.5	183.0	226.7	208.1
1962	200.5	206.0	129.1	129.1	187.3	223.7	248.4	217.2	219.2
1963	120.6	236.9	144.1	144.1	107.9	131.1	99.9	243.5	156.3
1964	83.1	169.7	168.4	168.4	183.7	202.5	227.7	160.3	153.7
1965	165.5	201.2	178.1	178.1	240.4	194.6	252.6	211.0	215.8
1966	146.3	114.3	158.5	158.5	153.9	229.0	182.1	124.5	166.3
1967	117.1	120.5	150.9	150.9	89.8	107.3	79.5	113.0	27.2
1968	191.1	261.8	169.2	169.2	260.2	178.7	211.9	240.5	234.3
1969	329.3	254.5	215.6	215.6	218.1	170.8	214.4	299.2	279.3
1970	119.0	185.7	221.1	221.1	96.0	215.8	145.9	78.8	109.0
1971	133.0	177.7	195.7	195.7	129.5	128.5	150.8	249.2	142.3
1972	290.2	257.5	248.8	249.8	230.3	194.6	196.4	235.2	247.5
1973	94.3	139.0	145.3	145.3	191.3	199.9	207.4	120.8	115.4
1974	212.0	223.7	290.8	290.8	310.6	252.8	296.2	191.0	293.2
1975	150.3	185.8	136.4	136.4	116.1	176.1	126.8	134.5	97.7
1976	264.3	230.1	242.3	242.3	195.7	186.7	198.5	164.8	161.4

YEAR	ACTUAL YIELD	TOTAL RAINFALL	MONTHLY RAINFALL	MONTHLE & TOTAL RAINFALL	MONTHLY MAX. TEMPERATURE	MONTHLY MIN. TEMPERATURE	MONTHLY MEAN TEMPERATURE	RELATIVE HUMIDITY	SELECTED VARIABLES
1950	148.5	235.7	135.5	135.5	158.1	190.1	192.8	223.6	171.8
1951	109.0	106.0	161.3	161.3	99.2	146.0	129.9	194.6	131.9
1952	93.7	163.1	177.5	177.5	165.8	199.0	196.2	153.1	155.4
1953	340.6	157.1	150.5	150.5	219.9	228.4	221.9	272.2	261.9
1954	484.5	274.4	345.2	345.2	348.3	234.3	276.9	324.6	381.6
1955	150.8	162.4	138.6	138.6	160.4	166.6	162.6	157.0	154.4
1956	216.5	150.6	169.2	169.2	217.0	199.0	206.3	236.9	232.2
1957	295.3	321.9	366.8	366.8	213.1	225.5	206.3	307.4	287.4
1958	124.8	92.3	124.7	124.7	173.5	187.2	219.8	45.8	96.9
1959	179.2	231.7	208.2	208.2	166.8	184.2	199.6	123.2	184.1
1960	104.0	85.0	142.2	142.2	186.5	207.8	202.9	167.2	171.8
1961	216.2	176.4	134.2	134.2	209.9	166.6	186.1	251.8	239.3
1962	200.5	213.3	122.1	122.1	258.3	231.3	260.1	202.4	248.6
1963	120.6	248.3	138.2	138.2	90.9	123.3	88.6	251.9	168.7
1964	83.1	172.3	164.2	164.2	206.8	207.8	189.5	124.0	150.3
1965	165.5	207.9	174.6	174.6	268.5	199.0	202.9	280.8	254.7
1966	146.3	109.6	153.6	153.6	155.3	237.2	213.0	127.2	156.4
1967	117.1	116.6	145.5	145.5	55.9	101.8	48.2	127.2	23.3
1968	191.1	276.5	165.1	165.1	255.4	181.3	229.9	222.0	268.0
1969	329.3	269.1	214.8	214.8	239.6	172.5	182.8	312.9	272.1
1970	118.0	190.3	220.7	220.7	127.4	222.5	213.0	114.7	109.4
1971	133.0	181.3	193.5	193.5	169.5	125.4	108.8	203.9	207.6
1972	290.2	271.6	250.3	250.3	212.1	199.0	219.8	224.3	248.6
1973	94.3	137.5	139.4	139.4	201.8	204.9	202.9	91.9	145.2
1974	212.0	233.3	295.3	295.3	305.1	263.7	266.9	236.1	270.1
1975	150.3	190.5	129.9	129.9	124.0	178.4	176.0	109.2	118.6
1976	264.3	240.6	243.4	243.4	193.6	190.1	186.1	170.3	171.8