SOIL SCIENCE DIVISION

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PROCEEDINGS OF THE VIII INTERNATIONAL FORUM ON SOIL TAXONOMY AND AGROTECHNOLOGY TRANSFER

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THE ARAB CENTER
FOR THE STUDIES OF ARID ZONES AND DRY LANDS
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I. Preface

The project of the Arab Centre for the Study of Arid Zones and Dry Lands (ACSAD) to make a soil map of the Arab countries is both challenging and rewarding. Maintaining the quality and uniformity of the map is a difficult task, but in order for the map to serve its purpose--to serve as the basis for agrotechnology transfer between countries of the region--it is essential that each country maintains and ensures this quality and uniformity. It is partly for this reason that this series of Forums is organized.

The Soil Management Support Services (SMSS) of the Agency for International Development has had long association with ACSAD, and more specifically, the Soil Map Project. The forum in Jordan is the eighth in the series that SMSS has organized worldwide, and the second in the Arab countries. SMSS has also organized two Soil Classification Workshops in the region--Syria and Lebanon in 1978, and in Sudan in 1981.

We hope to create a greater awareness for Soil Taxonomy through these Forums and Workshops. Soil Taxonomy can and should play a greater role in agricultural development. Having the largest extent of deserts in the world and with decertification a constant threat, the Arab countries have a serious problem maintaining their arable land and assuring sustained, if not increased production. A judicious use of the land through discriminatory land use policy is crucial and these are some of the areas of discussion in these Forums.

The VIIIth Forum has been an outstanding success due largely to the contributions of the Ministry of Agriculture of Jordan. The logistic support provided by the staff of ACSAD ensured this success. We were also fortunate to have some of the most renowned soil scientists to lecture. The interest and enthusiasm of the participants made this effort of ACSAD and SMSS rewarding.

Hari Eswaran
January 1985

II. FOREWARD

The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) is an Arab League Organization established in 1972 with a headquarter in Damascus/ Syria . Its terms of reference include the survey, the evaluation and the conservation of the natural resources in the Arab countries. The soil/land resources survey is an important project that started since 1975. To fulfill the objectives of this programme several activities were initiated among them are :

1. The standardization of the methodology to be adopted by all Arab soil scientists at the field and the laboratory level.

2. The adoption of an international soil classification system that is the USDA Soil Taxonomy .

3. The creation of a scientific dialogue among Arab soil scientists .

4. The improvement of the Soil Taxonomy system to be applied properly to the soils of the Arab countries .

5. The initiation of soil research management in the arid and semi-arid regions to increase agricultural production .

6. The development of the soil moisture and temperature regimes in the arid and semi-arid regions.

7. The training of the Arab soil scientists in the application of these technologies .

8. The correlation among available soil/land classification systems that were applied in the Arab countries .

The training activity has no doubt the most important impact on the progress of the project. Several training courses, seminars and workshops have been prepared and realized with great success. These proceedings reflect partially the results of the VIII The International Forum on Soil Taxonomy and Agrotechnology Transfer that was held in Jordan 14 - 25 May 1984 with the cooperation of the Soil Management Support Service (SMSS) of the Agency for International Development (AID) . The Hashemite Kingdom of Jordan has contributed efficiently in this forum by several professors and soil scientists . Other contributions were presented by Prof. Dr. R. Tavernier , Dr. W.Johnson, Prof. Dr. F.Moormann and Prof. Dr. F.Beinroth . The trainees themselves have participated actively in the success of this programme. ACSAD Administrators and scientists have given full support to this Forum.

Sincere appreciation is expressed to all these individuals and Institutions .

A.OSMAN

ACSAD

III. TECHNICAL PAPERS

THE USE OF SOIL TAXONOMY IN SOIL SURVEY PROGRAMS

BY : WILLIAM M. JOHNSON

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A soil survey includes the identification and classification of different soils in the field, the location of the boundaries of different kinds of soils in the field, plotting those boundaries on a base map, description of the soils shown by the map including the morphology and statements about the important characteristics and qualities, and finally, interpretations of the map units especially for the purposes for which the soil survey was made.

Orders Of Soil Survey

Soil surveys can be made at different degrees of intensity, depending on the objectives and on the conditions in the survey area. It should be clear that one would not make the same kind of survey in the Arabian desert as in an area of irrigated land adjacent to the city of Damascus .

Soil surveys have been characterised as (a) exploratory (the broadest, most general, with the smallest scales) : (b) reconnaissance, of intermediate scales, with mapping done by traverses without actual observations between the traverses; and (c) detailed, the most intensive, at largest scales, in which boundaries of the soils are observed throughout their courses. In recent years a somewhat more quantitative classification of " orders " of soil surveys has been developed .

Table /1/ below gives the features of each of the 5 orders of soil survey :

Requirements of Soil Surveys

Soil surveys are expensive to make. Order II. surveys costs $2 to $3 per hectar or more, counting publication . Even Order III surveys generally cost more than $1 per hectar. No private institution or government is likely to spend this amount of money unless it can be shown that soil surveys are useful enough to repay their costs.

A soil survey is thus expected to be of immediate and considerable practical use. In a few cases documented in the United States , it has been shown that the survey has repaid its costs several times over in avoidance of expensive errors in soil use and management and in increased profits to the cultivators. In some other instances surveys have failed because they did not help planners, cultivators, government and other institutions to improve soil use and management, perhaps because not enough detailed was mapped, or because the wrong kind of detail were shown .

In some other instances soil surveys have failed because they were unreliable. The directors of such surveys did not provide and maintain the proper scientific guidelines to insure a high-quality product that met the objectives for which it was made.

It is clear that soil surveys must be conducted with reasonable scientific standards and they must have practical objectives to be useful They must be useful to be supported with public funds. Governments have too many demands on their funds to pay for expensive projects that have no practical value.

Application of Taxonomy to Soil Survey

The soil survey requires a classification that makes possible comparisons of soils for both similarities and differences. It uses soil classification to determine what experience and test data are applicable to the soils of a specific tract of land. The classification is the vehicle by which soil scientists transfer the research and farmer's experience from one area to another with confidence that the transfer is reliable. It makes

it unnecessary to conduct research for soil management on every field and farm. This puts a heavy burden on the soil classification. Large numbers of individuals with very diverse backgrounds and training are expected to use the classification accurately to transfer experience with soils. Insofar as possible, the classification should have the following qualities :

1. It must be a system that can be applied uniformly by competent soil scientists working independently but having diverse kinds of education and experience . This requires that the classification proceed from the properties of the soil itself and not from the believes of the classifier about soils in general.

2. The system must be comprehensive, designed to permit the inclusion of all soils.

3. It should be a multi categoric system, with a few taxa in the highest category and a large number in the lowest category. The lower taxa of the classification must be as specific as possible about a great many soil properties. Higher categories are essential for comparisons of the soils of large areas, but are of limited value for the transfer of experience.

4. Taxa should be defined in terms of observable or measurable soil properties, selected primarily to group soils of similar genesis. Dominant genetic processes leave their " marks " in the soil.

5. Defenitions should be in terms of operations, so that they carry the same meaning to each user. We may not say that " a soil has high base saturation " because what is high in one place is low in another.

6. The taxa must be concepts of real bodies of soil, i.e. polypedons that have geographic areas and are not merely ideas or mental concepts.

7. The classification should be capable of modification to fit new knowledge with a minimum of disturbance .

TABLE 1 : Orders of Soil Surveys

ORDER I. The most intensive and detailed kind of survey, done for research projects and for the most highly intensive soil uses.
Mapping scale less than 1:12,000.
Minimum aize of delineation 0.6 ha or smaller
Map units : Phases of soil series .

ORDER II. The usual detailed survey made in humid regions for intensive soil management for crop production .
Mapping scale 1:12,000 to 1:31,680 .
Minimum size of delineation 0.6 - 4 ha.
Map units : Association and complexes of phses of soil series .

ORDER III. High-intensity reconnaissance or low-intensity detailed surveys, generally made for soil management for grazing, forestry, other less intensive uses.
Mapping scale 1:24,000 - 1:250,000
Minimum size of delineation 4-260 ha
Map units : Associations of phases of series

ORDER IV. Low-intensity reconnaissance surveys made for broad planning purposes .
Mapping scale 1:100,000 - 1:300,000
Minimum size of delineation 40-400 ha
Map units : Associations of soil families .

ORDER V. Exploratory surveys to locate areas with potential for farming , irrigation, grazing, and forestry. To locate areas where more detailed surveys are needed .
Mapping scale 1;250,000 - 1:1million
Minimum size of delineation 260-4,000 ha.
Map units : Association of phases of categories higher than the soil family.

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Cline* has given a thorough critique of Soil Taxonomy with respect to its suitability for use by the soil survey. The quotations below are taken from his paper .

" The system has been developed deliberately to place soils thought to have had similar genesis in the same group . The groups, however, have been defined equally deliberately in terms of soil properties without reference to genesis. Clearly, the bases on which the classes have been formed are genetic considerations , and in this sense the system is based on genesis. The criteria by means of which the classes are differentiated, both in the written outline of the system and in practice in the field, however, are soil properties. In this case, also at least one step of reasoning is necessary to develop genetic interpretations from the definitions of the classes .

" If the classes were defined in terms of either direct interpretations for applied objectives or in terms of theories of genesis, the definitions would prejudice future experience by directing understanding of them into channels of past experience and , more importantly, by defining reality in terms of theories, which will certainly change. Future experience is prejudiced in the system inspite of factual definitions, because genetic theory has directed the choice of criteria and practical considerations have influenced their applications. That prejudice, however, is in terms of mechanics of the system,not in terms of correspondence of classes to real things. The system deliberately subordinates both genetic and practical considerations to quantitative definitions in terms of soil properties, which are fact within the limits of operational measurements. These definitions provide a built-in test of theory. This, in the judgment of this author, is the most important single attribute of the system."

"A class of a taxonomic system must be defined in terms that hold wherever and whenever that class is encountered ".

"...the system is oncomplete in terms of classes, criteria of classes, and precision of definition of criteria of classes to varying degrees related to the amount, validity, and genetic correlations of data available . The system

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* Cline, M.G. 1963 . The new soil calssification system. Cornell University Agronomy Memo No. 62-6.

is'open ended' , and subject to additions to all three of the elements mentioned. Every class in the system currently is known to have a counterpart in reality, and the criteria by which it is differentiated are known to be properties of that reality and to be definable in terms of operations.

"Probably the most important feature of the system is the fact it contains a built-in mechanism to destroy itself, in part or in whole. Each application of definitive properties to a real soil can be a test of the validity of the choice and definition of those properties. Collectively, they should force the exposure of false hypothese and concepts that have been elements governing the choice and definition of criteria. This is a guarantee against prejudice of future experience and a tool that sheul force better understanding" .

In summary, we believe that Soil Taxonomy is the most useful classification system yet devised for use in soil surveys. Experience has shown that soil scientists on opposite sides of the world, with vastly different backgrounds of training and experience, can use the system consistently and accurately. It is true that Taxonomy is not accepted everywhere and that it has been strongly criticized by some. It appears, though, that the most vigorous criticisms come from individuals who know little about the system and understand even less. The system generates a lot of argument even among those in the United States who use it every day in their work but this is normal. They argue about a few minor points in question, while remaining silent on the vast body of agreement. We encourage those discussions and arguments, because they lead to more study and thought about ways in which we can improve Taxonomy . As you work with the system, I hope that you , too, will raise questions and make proposals for its improvement.

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THE NEED FOR A WORLDWIDE SYSTEM OF SOIL CLASSIFICATION

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The need mentioned in this title is a composite requirement, the statement can be broken down as follows :

- need for classification . Why is classification, any classification needed.
- need for soil classification
- need for a system of soil classification, and finally :
- need for a worlwide or international system of soil classification

The different aspects of the statement will be briefly discussed.

Need for classification :

Classification is inherent in human life and is an integral part of our language . Names of objects are at the same time an element of classification; descriptive , adjectives specify the properties of the object as in: ("a large danish dog" and " a small pekinese dog ") .

Cline [1] pointed out that classifications are orderly abstracts of knowledge , and of concepts derived from knowledge ..... . He stated : "The purpose of any classification is so to organize our knowledge that the properties of objects may be remembered and their relationship may be understood most easily for a specific objective ".

We need, therefore, classification(s) to organize our knowledge of objects , data, theories, concepts into welldefined patterns units.

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(1) quotes are from : Guy D.Smith : Lectures on Soil Classification Pedology 1965-4

We can with little exageration state that we continuously classify the objects around us : we name them , put them in the context of our every days life, relate them and draw conclusions from such relationships .

Need for soil classification :

In Soil Taxonomy the concept of soil individuals which require grouping or classification is essential . Our concept of an individual is conditioned by our experience : we can recognize a cat, a dog, an oak without difficulty. The concept of a soil individual is much more difficult because , with few exceptions soil individuals are parts of a continum . Soil Taxonomy use the notion of pedon i.e. the smallest volume that may be called " a soil" . Normally "a soil" consists of many contiguous similar pedons, and is called a "polypedon" .

Such polypedons or soil individuals can be described, and can be given names .

The need to group or classify soils (polypedons) and to name them has been alive since mankind has made use of soils to produce crops or to put them to any of the multitude of uses (or misuses) that soils have been submitted to . Specific descriptions of soils for different uses are old and existed long before our time, like in China . Interesting certainly are the descriptions, some 2000 years old, in Vergilius " Georgie" . He describes heavy or clayey soils and light or sandy soils in view of their use and management . He mentions the kind of soils good for vineyards for various kinds of corn, etc. In terms of management he indicates on which soils, heavy growth of bad needs may be expected . Vergilius even gives some advice on on soil studies for practical purposes : if you dig a hole and refill it, the soil has a bad structure if after the refill, you may have some soil left. When the structure is good, there is not enough soil to fill the hole completely . We can easily translate this kind of observation in modern terms of ped arrangement, pore space, bulk density and the like, but the fact remains that the need for a descriptive and utilitarian soil classification is very old indeed .

Need for a system of soil classification :

Vergilius, the Latin writer did classify soils, but not in a systematic way . He would single out soils, good for vineyards for corn, for other uses, and subsequently be described the desirable characteristics of such soils (or the undesirable ones) .

One of the earliest scientists who understood the need for a natural system of soil classification was DOKUCHAEV . Travelling as he did in the immense and (geologically) rather uniform plains of the Eurasian continent, he did not only notice the variability of the soils that he saw, but also the factors causing that variability . This was the birth of the genetic system of soil calssification .

The Russian schools after DOKUCHAEV developed the grouping of soils in zones . The zonal soils of Sibertsev et al. represent a grouping of soils largely by genetic theory . Even the present-day system in the USSR uses climate per se' to define soil classes as : tundra soils, desert soils etc.

In other countries too, knowledge on soils was coordinated into various systems of soil classifications both in west Europe and in America were mostly based on the lithology of the soil materials. Early in this century, however, after translation of major Russian publications, the genetic ideas which started mainly with DOKUCHAEV were incorporated in the various systems . Although these systems were multi-categorical, mostly they did not cater very well to the needs of the simple soil surveyor who had the task to bring some order in the mass of data assembled on soil individuals, soil series and soil "types" .

In the U.S. , and presently also in countries outside of the US soil classification took a new road in the post-war years . The need to make orderly groupings of the multitude different soils recognized at the lowest or series level, described analized and surveyed required a new approach in soil classification . This was the "Soil Taxonomy", conceived in the late fourties and the subsequent decades. Rather than classifying genetic processes or factors of soil information, as in the purely genetic systems, the new taxonomy classifies soils on the basis of their properties inherited from the environment or developed by processes of soil formation . The need,

leading to the development of Soil Taxonomy was therefore a typical progmatic need : the amount of measured and precise data on soils had since the beginning of this century become so enormous that a well ordered, multicategorical taxonomie system of classification became a necessity . It is the merit of the US group of soil scientists and some of their European colleagues and more in particular of Dr. Guy D.Smith, to have taken the lead in the development of this system .

Need for a worldwide system of soil classification

Most, if not all soil classification systems were developed in a national or even local context. For instance, the system used in 1955-1957 to make a soil map of eastern Jordan (EPTA-FAO report No. 1132) was based (partly) on an international system but the units distinguished are in fact national . Thus nowhere a "brown mediterranean" soil taxon existed at the time the Jordan map was made.

Some systems were set-up per international use. The systems best known in this respect are :
the French CPCS system of 1967, the FAO legend of the soil map of the world (not a classification, but a legend of the soil map) and of course, the USDA Soil Taxonomy .

Are these systems indeed worldwide, can they be used everywhere without changes, adaptations ? The answer is in effect : no . If we limit ourselves a moment to Soil Taxonomy, we read in the preface that the 1975 edition gives information on the present status of the taxonomy being used in the United States and several other countries. Hence even Soil Taxonomy is not worldwide , and for many areas, like parts of the trpoics, the system is indeed incomplete certain taxa, for instance those that have been altered by artificial floading are not incorporated .

Thus even the most complete of the international systems, Soil Taxonomy, is not yet a truly worldwide system . Soil Taxonomy, however, has all the ingredients to become a worldwide reference system. In many areas and for many t[illegible] it can be used on a worldwide scale . Soils from Canada,

from the great plains in the US , from the black soil zone in Russia can be uniformaly classified with the system to a low level of generalization, e.g. the subgroup or even the family .

In other region of the world, in other taxa of the system we find that such a worldwide application is not or at least not yet possible. Changes and additions are required to make the system really universal.

Inherent in Soil Taxonomy is that it is capable of modification to fit new knowledge . This is a crucial property of the system which in my opinion makes it superior to most if not all other systems. Add to this that indeed the system is now in worldwide use and we can state that it is fulfilling the requirement for a "worldwide" usable mechanism for classifying soils .

Conclusions :

Even now, in its "incomplete" form, Soil Taxonomy as a system which can be applied worldwide , provides for a multitude of needs of which a few may be mentioned in conclusion :

- it leaves as a logical framework to study and compare soils, their morphology and their chemical and physical properties .
- as a necessary aid to study genetic and landscape relationships between soil individuals
- as an international soil language, a means of communications, whereby the objects we discuss are precisely measured and defined . Thus identical taxa are identically defined and should have the same meaning for all soil scientists .
- as a vehicle of technology transfer, because on very similar soils (under very similar climates) often the same management techniques can be applied I say"similar" and not " identical" because even with virtually identical soils, conditions required for optimum management are never identical.

On several of the subjects, mentioned above, more discussions will take place during this forum. I am convinced however that at the closing of the forum most of you will be convinced of the need for a worldwide system of soil classification . I do hope sincerely that you will also be convinced of the important role that " Soil Taxonomy" will have to play to meet this need of the international community of students and users of the soils .

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CLIMATE OF JORDAN

BY: DR.Y. EL KAWASMA
Head of Climate Section - ACSAD

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1. INTRODUCTION :

The country lies in the East Mediterranean climatic region between latitudes 29° 32 and 32° 42 north and longitudes 35° 15° east. Its total area ia about 100.000 Km2 .

The country has very well defined topographical features. Jordan can be divided into three regions in this respect :

A. The Jordan Valley

This area is enclosed between the steep high mountains in the west and the east .

It extends some 400 Km from the north to the head of the Gulf of AQABA. It is the area in which Jordan river and the Dead Sea are situated Altitude ranges from 197m below mean Sea level in the north to Slightly mor than 392 m near the Dead Sea . The width of this valley range from 32 to 10 Km .

B. The Hilly Region

This region seperate Jordan Valley from the Steppe region (Region C). Altitude increase from west to east to about 12000 meter in north and to about 1500 meter in the south. Then altitude decreases gradually eastward toward region C .

C. The Steppe Region

This region lies in the east and south east of the country, and is

the largest region. It is rather level with altitude between 600-800 meter above mean sea level with some isolated mountain up to about 1700 meters above mean sea level in south (Jabbal Rum) .

2. THE CLIMATE

2.1 CLIMATIC CLASSIFICATIONS :

According to Koppen classification system the following climatic types exists in Jordan (Map 1) .

1-BWh : Arid (Warm hot desert)
2-BWk : Arid (Cool desert)
3-BSh : Semi-arid (Warm or hot steppe)
4-BSk : Semi-arid (Cool steppe)
5-CSa : Mediterranean - subtropical (dry warm or hot summer and rainy winter) Humid
6-Csb : Mediterranean (dry cool summer and rainy winter) Humid.

According to Thornthwaite : four type are presents in the country (Map 2) . These types are as follows :

1. Arid (E)
2. Dry Semi-arid (D_1)
3. Semi-arid(D_2)
4. Moist semi-arid(D_3)

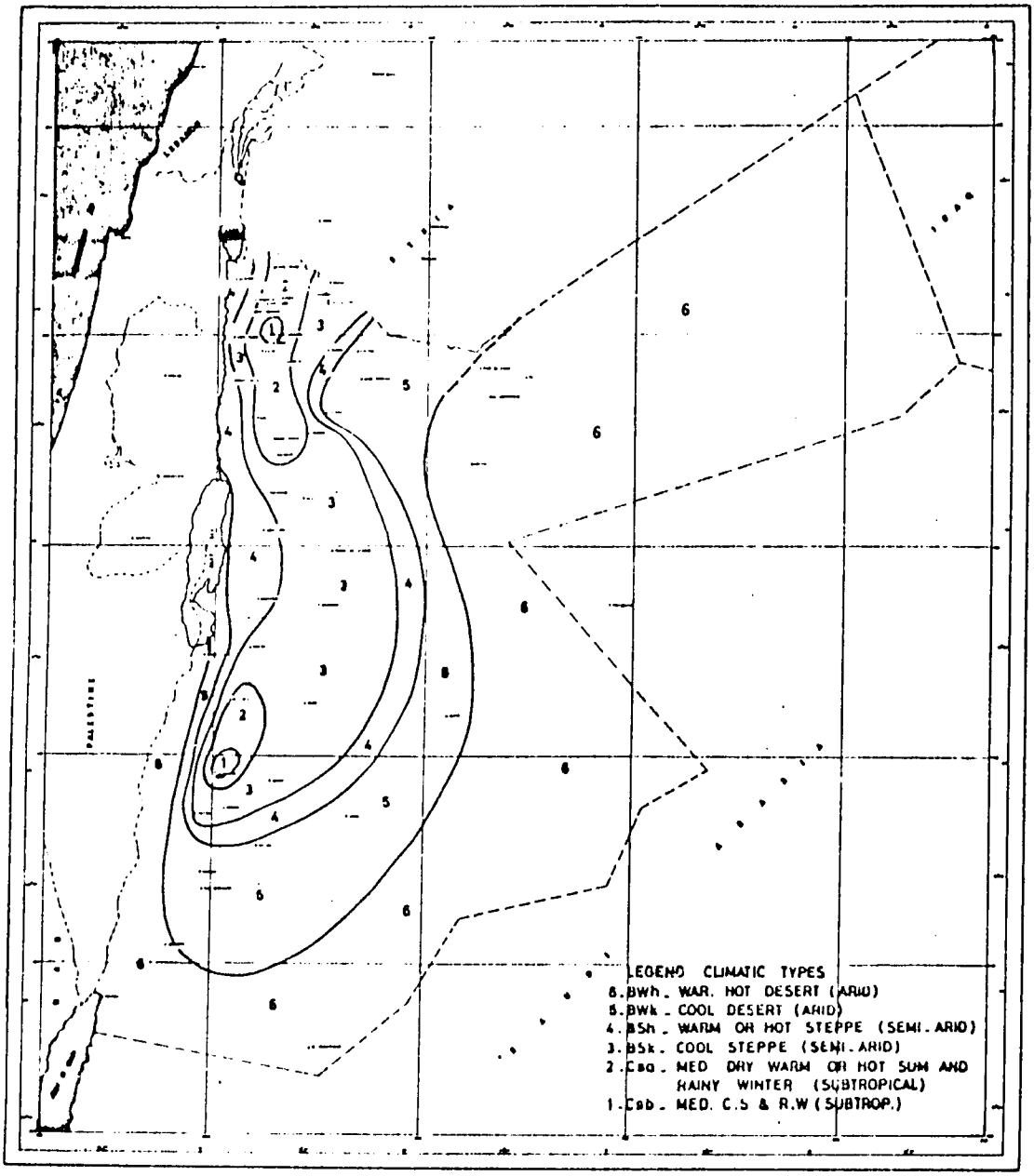
Types (3 & 4) in Thornthwaite approach or types (5&6) according to Koppen represent very small area of the country.

In general one can easily say that more than 60 % of the country lies in the Arid areas. This indicate the severity of the prevailing climate over the country.

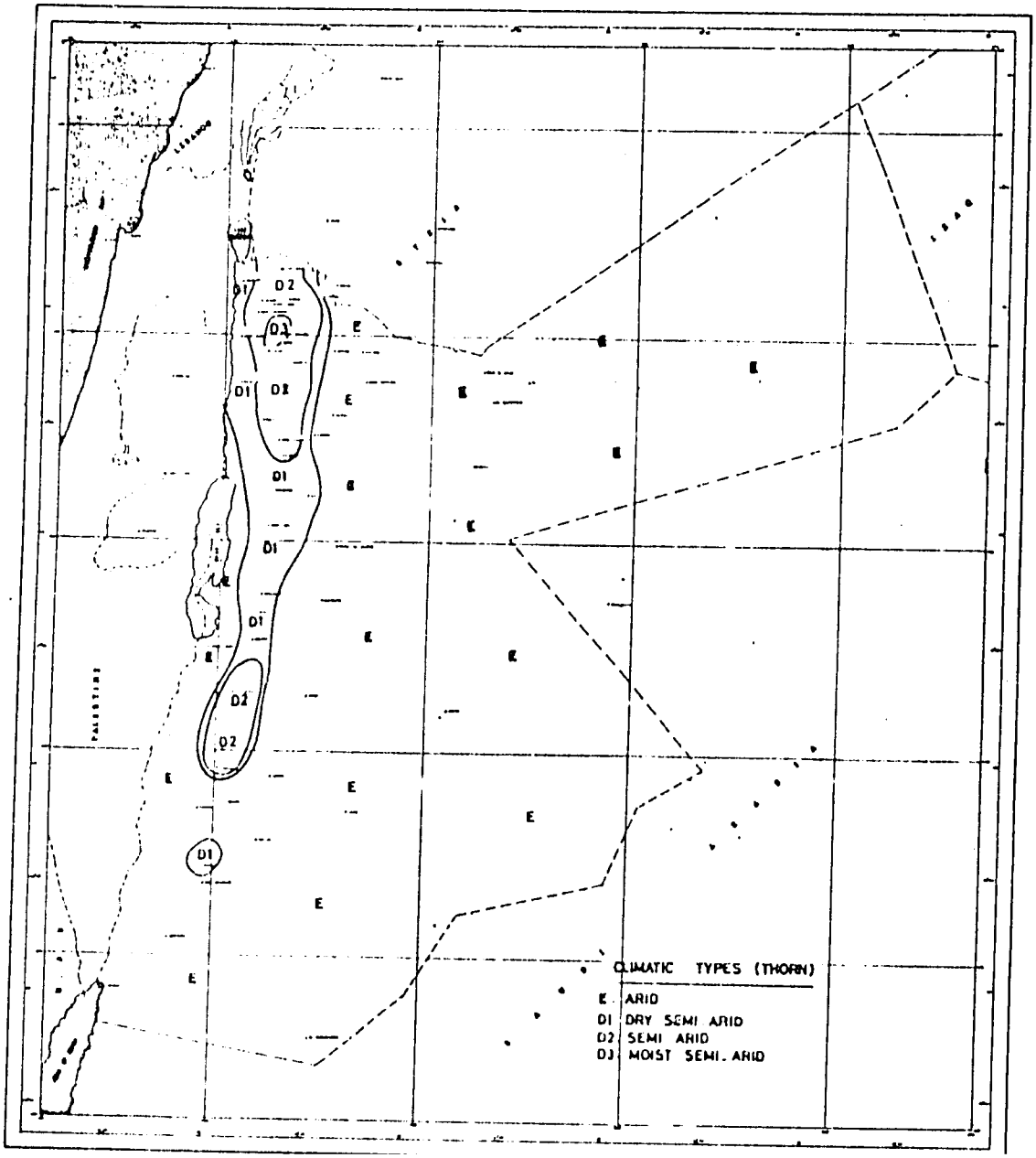
2.2 RAINFALL :

Rainfall usually starts in October and ends in April with the possibility of scattered showers in September and May. The total annual rainfall over the country is very much related to topography. Highest amount of rainfall occur in the mountain region (Map 3).

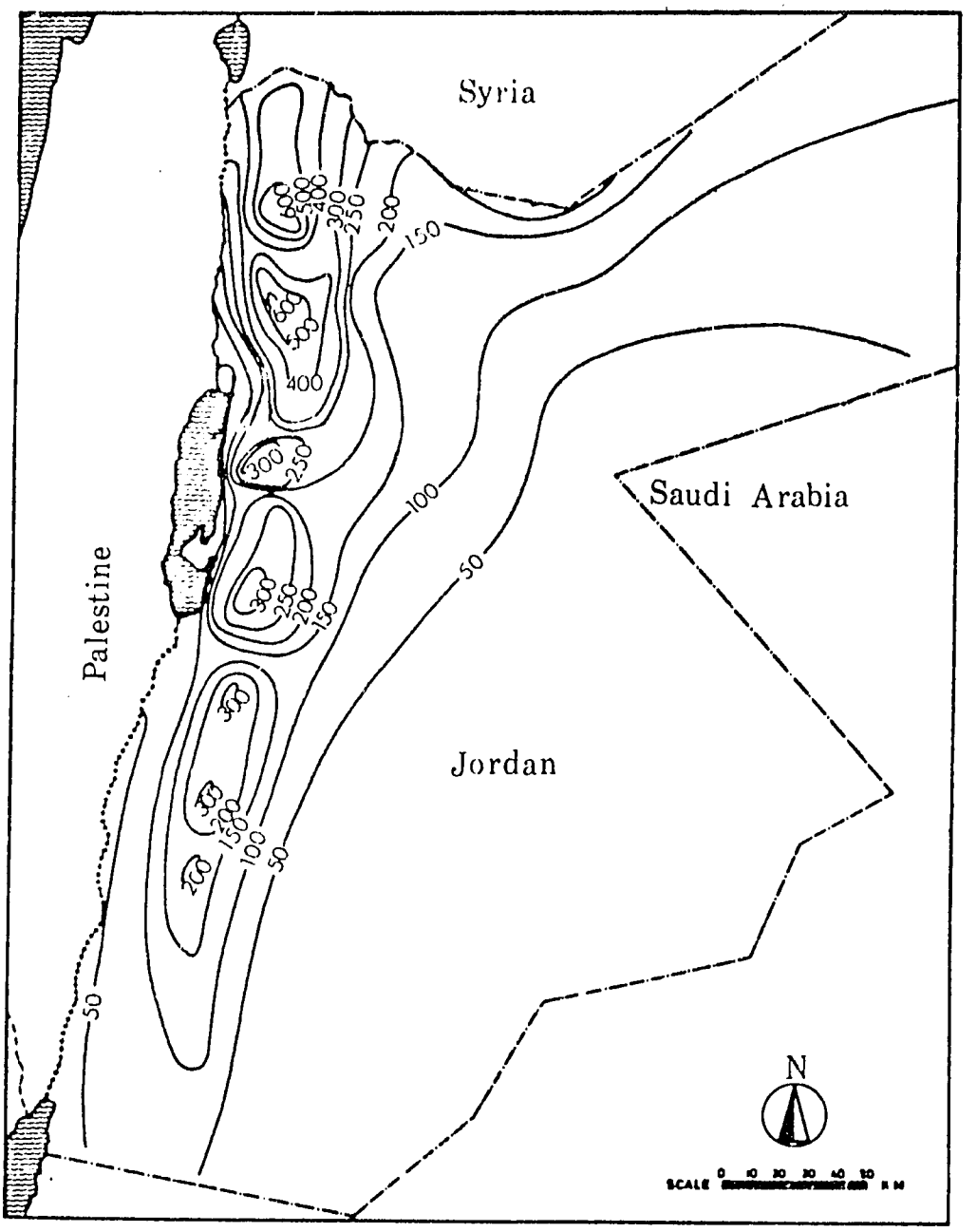
MAP 1


LEGEND CLIMATIC TYPES
6. BWh - WAR. HOT DESERT (ARID)
5. BWk - COOL DESERT (ARID)
4. BSh - WARM OR HOT STEPPE (SEMI-ARID)
3. BSk - COOL STEPPE (SEMI-ARID)
2. Csa - MED DRY WARM OR HOT SUM AND RAINY WINTER (SUBTROPICAL)
1. Csb - MED. C.S & R.W (SUBTROP.)

MAP 2


CLIMATIC TYPES (THORN)
E ARID
D1 DRY SEMI ARID
D2 SEMI ARID
D3 MOIST SEMI. ARID

MAP 3 RAINFALL DISTRIBUTION: ISOHYETS



Rainfall at any latitude increase from Jordan valley up to the mountain region, then decrease eastwards. Also there is a drop of rainfall from north to south . It is enough to say that 50% of the country is receiving less than 100 mm/year. Annual rainfall is changeable from year to year, the uncertainity mostly is function of the amount of this annual rainfall i.e. areas of higher rainfall are more stable than areas of lower rainfall.

With respect to distribution, in general about 50% of rainfall takes place in the period Dec. - Jan. Maximum monthly rainfall usually is in Jan. (See table 1) . What is more important for this distribution is the variability from year to year. For most locations even for the most rainy regions the coefficient of variation is more than 45% for the wettest month . This is an indication that monthly rainfall is very highly unstable.

Another important feature of rainfall characteristics is the high intensity . This might be demonstrated by considering the absolute maximum monthly and the maximum daily record for different locations in the different regions in the country (table 2) .

These previous general characteristics of rainfall (variability erratic distribution and high intensity) are considered one of the major hazards for rain water utilization for Agricultural purposes . A complete and detailed studies need to concentrate on : First, the efficiency of this rainfall and second on probability of this rainfall. Considering the problem of efficiency and under certain conditions, this is found to be rather low (can be estimated) . The seasonal rainfall efficiency (Nov-May) is about 89% (AMMAN), 66% (JUBEIHA) 75% (IRBID) 63% (RAS MUNIEF) and 75% (SHOUBAK) . This efficiency is in the case of rather low slope and under medium infiltration rate.

2.3 TEMPERATURE REGIME :

The temperature regims over the country vary from region to region being mostly dependent on topography.

In the Jordan valley and the AQABA , the climate is mostly subtropical, characterized by hot summer and rather warm winter . In warmest

TABLE (1) MEAN MONTHLY RAINFALL(MM).

Month/Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Ajlun	12.6	46.8	117.3	146.5	111.0	103.9	41.1	6.9
IRBID	12.3	40.7	87.8	104.6	74.2	77.4	30.4	6.9
JARASH	6.9	30.1	36.1	78.8	65.7	62.7	24.8	3.6
MAFRAQ	4.6	13.8	25.6	35.1	27.1	24.5	10.5	3.2
JUBEIHA	9.0	33.8	88.0	108.8	88.4	85.4	33.0	4.4
MADABA	6.1	28.9	53.3	70.7	55.3	57.4	32.4	3.3
SHOUBAK	4.1	19.9	63.9	71.5	51.0	47.6	22.3	4.8
PETRA	1.1	7.3	37.9	24.3	25.0	23.8	11.3	0.6
DEIRALLA	7.1	28.0	52.8	63.8	48.0	43.9	21.4	3.8

TABLE (2)

COMPARISON OF MAXIMUM MONTHLY AND MAXIMUM DAILY VALUES OF RAINFALL WITH ANNUAL RAINFALL

Element Region	Station	Annual mean mm	Monthly maximum mm	Daily maximum mm	PERCENTAGE	
					MONTHLY / Annual	DAILY / Annual
Hilly	IRBID	435	270	105	062	024
	SHOUBAK	285	352	074	123	026
	KARAK	339	286	115	084	034
Jordan Valley	BAQURA	365	210	049	057	013
	DEIRALLA	269	225	050	084	019
Steppe & ALABA	MAFRAQ	144	099	044	068	030
	PETRA	131	178	085	136	065
	ALABA	033	067	065	206	199

month (either July or August), the mean monthly temperature for July is about 31°C mean maximum 39°C, absolute maximum (highest record) is 52°C. But in the coldest month (January), the average, mean minimum and absolute minimum are 15°C , 8-10°C and Zero respectively. Frost in this region is rather rare (2-3) times a year especially in the north and middle of the Valley.

In th. illy region, the climate is fine in summer and rather cold in winter. In January (the coldest month) mean temperature range from 6-8°C, mean minimum 3-4°C and minimum temperature drop to 9°C below freezing . In August (Warmest month) , mean temperature , maximum and absolute maximum are 24°c , 30-33°C and about 43°C respectively.

In the steppe region, the climate is very near to continental one i.e. with a large temperature amplitude. It is very cold in winter and rather hot in summer. In January, the daily average, the mean minimum and the absolute minimum are as follows : 9°C , 2-3°C and 12°C. In August , the average daily mean, daily maximum and the absolute maximum are 19°C , 39°C, and 47°C . (see table 3 and Map 4)

2.4 Potential Evapotranspiration :

One of the major hazard facing the country is the high values of potential evapotranspiration (the atmospheric demand) . Map 5 represent the annual distribution over the country, table 4 represent the monthly values for selected locations in the country according to Penman methods.

It is well demonstrated that the atmospheric demand is above 1200mm for the coldest regions and might goes up to around 2000 mm as near AQABA.

One of the major characteristics with respect to distribution is that lowest values are taking place during the rainy season, highest values during the summer (non rainy period) This is the reason why dry farming is possible in some part of the country.

If one combine rainfall with potential evapotranpiration, he can

TABLE (3) MEAN MONTHLY TEMPERATURE C°

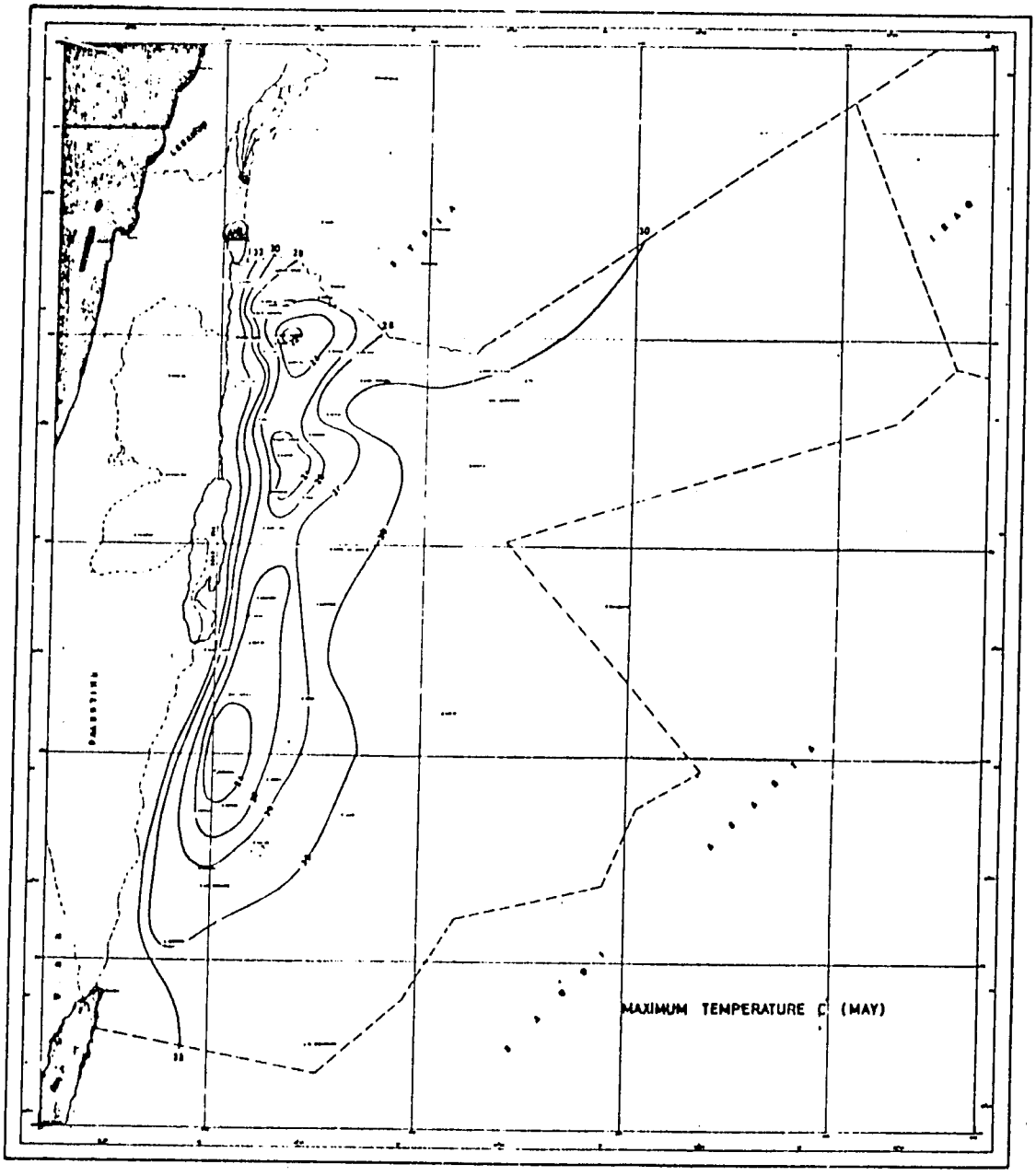
Month/Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
AMMAN	7.8	9.2	11.7	15.6	20.1	23.6	25.0	25.3	23.0	20.0	14.4	9.4
JUBEIHA	6.0	7.1	10.7	13.7	18.2	21.5	22.8	23.1	21.2	18.9	12.9	8.3
IRBID	8.9	9.9	12.3	16.1	20.4	23.7	25.1	25.6	23.7	20.9	15.7	10.7
SHOUBAK	4.3	5.4	8.2	11.8	15.0	18.2	19.9	20.2	17.7	14.9	9.9	5.9
DEIRALLA	14.8	15.7	18.1	21.9	26.1	29.1	30.8	31.3	29.6	26.7	21.9	16.4
BAQURA	13.4	14.5	16.7	20.5	24.9	28.4	30.1	30.7	28.9	25.4	20.2	15.1
MAFRAQ	7.3	8.8	11.6	15.6	19.8	22.8	24.0	24.3	22.3	19.1	13.6	8.9
AQABA	15.0	16.7	19.7	23.7	27.8	30.6	32.2	32.1	29.7	26.4	21.3	16.3

TABLE (4)

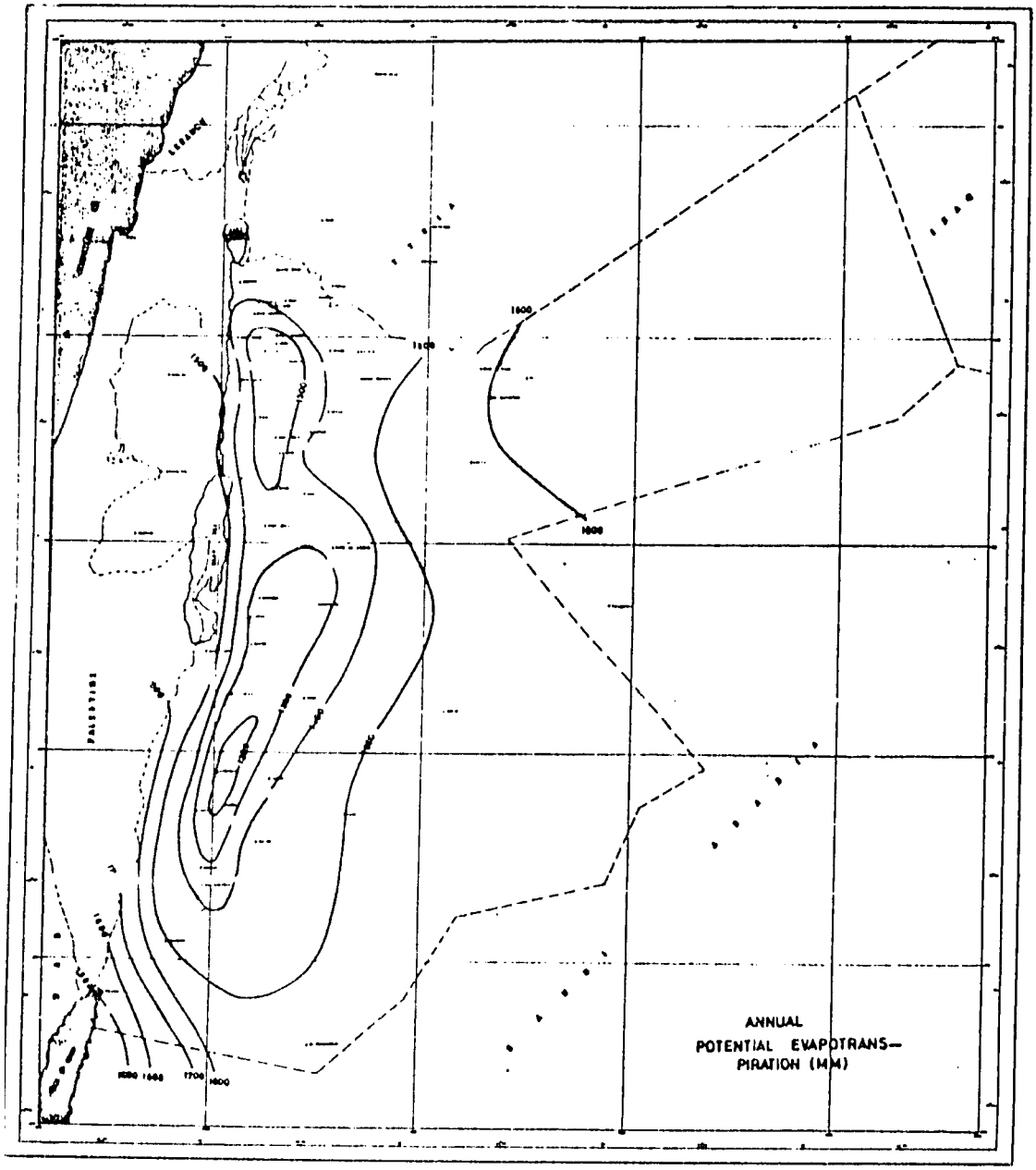
MEAN MONTHLY POTENTIAL EVAPOTRANSPIRATION (MM)

MONTH / STATION	Jan.	Feb.	Mar.	Apr.	May	Jun	July	Aug.	Sep.	Oct.	Nov.	Dec.
AMANN	36	49	76	112	170	205	219	201	154	114	66	36
JUBEIHA	21	36	64	098	155	182	193	182	136	096	51	21
IRBID	30	45	75	112	173	208	218	199	154	112	65	32
SHOUBAK	25	39	67	092	134	158	170	161	127	094	51	28
DEIRALLA	42	56	83	124	182	206	220	207	159	109	66	39
BAQURA	31	48	75	124	178	199	212	198	148	105	58	30
AQRABA	66	81	120	155	221	225	267	256	203	153	100	66
MAFRAQ	34	51	83	118	177	210	222	207	157	117	70	34
MA'AN	47	60	93	123	170	202	215	198	155	115	66	46

MAP 4



MAP 5


LEBANON
PALESTINE
1600
1100
1000
1700
1800
ANNUAL
POTENTIAL EVAPOTRANS-
PIRATION (MM)

get an information about the duration of the climatic growing period. It is found that this period varies from zero in the arid region to about 150 days in the moist semi-arid regions.

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RELATIONSHIPS BETWEEN AIR AND SOIL TEMPERATURE IN THE ARID - SEMI - ARID TROPICAL REGION IN JORDAN[1]

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****

ABSTRACT

Four stations that represent the arid to semi-arid tropical region in Jordan (Ghor Safi, Deir Alla, Wadi Yabis and El-Baquara) were used to study the relationships between maximum, mean and minimum air temperature and soil temperature measured at 1 cm, 5 cm, 10 cm, 20 cm, 30 cm, 60 cm , 100 cm, and 200 cm respectively. The measurements covered the 12 months of the year and were devided into three sets : summer months, winter months and the 12 months pooled in one set.

Regression analysis using the stepwise method was utilized to select the best , most significant equations descriping the relationships between air and soil temperature .

Analysis indicated significant and high correlation between air and soil temperature . Maximum correlation was between air temperature and soil temperature in the upper 50-60 cm. Below this depth correlation decreased sharply . Moreover, correlation values were highest for

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1) Contribution of soil and irrigation Dept. Agric. College University of Jordan

equations describing relationship using 12 months together followed by those for winter and summer months respectively

Mean annual soil temperature at 50 cm was higher than mean annual air temperature by (1.8 - 2 °c). This difference is almost 1°c higher than those differences reported for most of the U.S.A. soils.

According to the USDA system of soil classification. The soils of this region would qualify to have the hyperthermic temperature regime.

INTRODUCTION :

Temperature is one of the most important properties of soils that control to a great extent the activity of organisms and processes of soil formation. At any time, soil temperature varies from one horizon to another. This variation can to a great extend, be contributed to the variation of air temperature .

The objective of this study was to investigate the relationship between air and soil temperature at various depths in the arid region and to determine the soil temperature for the soils in this area.

MATERIAL AND METHODS :

Four stations (El- Baquara (1), Wadi Yabis (2), Deir Allah (3), Ghor Safi (4) were used in this study. These stations are located in Jordan valley . (or what is called Jordan Rift Valley). (El-Baquara is located in the north and Ghor Safi is located south of the Dead Sea (Given number 1, 2, 3 and 4 on the maps) .

Annual precipitation in the valley varies from 400 mm near El-Baquara to 100 mm near Ghor Safi . Annual potential evapo-transpiration varies from 1300 mm near El-Baquara to 1680 mm near Ghor Safi . Mean annual air temperature, mean air temperature for the coldest month (January) and the warmest (August) are shown on map 1, 2, and 3 respectively (3). Topography in all stations was level, vegetation was annual grass.

Soil temperature (obtained from bulletins published 10 days by mateorological Dept.) was measured at the depth of 1, 5, 10, 20, 30, 50 or 60, 100 and 200 cm. The daily soil temperature represents average of several readings taken at 00, 06, 12 and 18 GMT . Maximum, Mean and Minimum air temperature were recorded. Each month was divided into three

equal periods . The average of ach 10 days was used in the statistical analysis. The measurements covered a period of 11 years (except Wadi Yabis only 4 years were available) .

The SPSS program was used in the statistical analysis. Polynomial regression using the stepwise method was utilized . The equation with the highest R and F values was chosen as P. Box 1964 . Criteria for judging adequancy of estimation by an approximation response function) to judge the adequancy of any model used as a predicting tool. Box suggested the value of the ratio of observed/ tabulated F should exceed 4 inorder to regard an equation as satisfactory predictor . Each table includes estimated equations relationship: soil temperature at various depth with air temperature in the following order : maximum, mean and minimum air temperature.

The results of the regressions analysis indicated that highly significant models can be obtained regarding the relationships between air and soil temperature (as indicated by the high R and Fc/Ft values). See tables 1-4 .

Most satisfactory models were those describing the relationships between air temperature and the soil temperature down to 50 or 60 cm. Below this depth, the relationships were less significant (though Fc/Ft was higher than 4 in some cases) and the R values were very low. The reliability of the computed models were further tested by plotting the measured (standarized values were used) soil temperature against the predicted soil temperature for various sets at different depths. Figures 4 - 7 show examples of such standarized plots drown for equation 3 of Deir Alla station . It can be clearly seen that highly linear relationship exists between predicted and measured values for the depth 1,5 . (10, 20, 30, 50 gave same pattern) . The satterplots for these depths were not presented here, but are available upon request). This relation ship was less linear for depths below the 50 or 60 cm and the best model describing the relationships between air and soil temperature at various soil depths.

The equations were estimated for threee different sets: The first set (designated by equation one in the tables) represents the measurements for the warmest months (May-October) . The second set (equation two) represents the coldest months (Nov. - April) . The third set (equation three) represents the 12 months of the year. The analysis included the estimated equations.

Multiple correlation and the ratio of calculated F/tabulated F. Tabulated F (12), 1,.005) was 8.18

RESULTS AND DISCUSSION :

Tables 1-4 summarize the results of the statistical analysis and the relationship between air and soil temperature . First column (1 or 2 or 3) designates the three different data sets. ST designate the depth where soil temperature (dependant variable) were measured (1, 5, 10, 20, 30,50 or 60, 100, 200 cm) . C is the intercept and b is the coefficient of the independent variable (air temperature) . Example (table 3 line 1) (ST 1-1 first set, depth equal. 1 cm) intercept = 21.4, b = .26 D03 (3) , Correlation coefficient = .59 calculated F/tabulated F= 12. Therefore, the equation that describes the relationship between maximum air temperature and soil temperature should be soil temp. (at 1cm) = 22.4 + .26 D 03 $(x)^3$. Where X is Mean Maximum air temperature . R is the multiple correlation coefficient . Fc/Ft is the ratio of calculated F/ tabulated F suggested by Dr. G.E.P.Box (M.Wet: and G.E. almost nonlinear at 200 cm . This was also reflected by lower R and Fc/Ft values .

In most cases, first order equation was the best obtained while for other cases polynomial model of second or third order gave the best fit. Furthermore, in general, the estimated R and Fc/Ft indicate significant relationships between air and soil temperature if the 12 months were considered together. The significance of these relationships was

lowest between air and soil temperature measured during summer months. This might suggest that the variation of soil temperature during the summer is effected by other climatic parameters other than air temperature .

The soil temperature at the depth of 50 cm was further investigated . This arises from two facts : first ; temperature values showed little variations below that depth (1) , second ; the soil temperature at this depth was chosen to determine the soil temperature regime as required in USDA soil taxonomy (4) . The prediction capability of the estimated equations was further investigated to find out the difference between soil temperatures (during the summer and winter months as defined by the USDA Soil Taxonomy) and those predicted by the equations estimated using set 1 (warmest mean air temperature) and set 2 (coldest mean air temperature) . As an example , estimated equations relating mean air temperature and soil temperature at the 50 cm depth were used .

Applying proper equations from table 1-5, it was found that (1) El-Baqura : while measured summer and winter soil temperature at 50 cm were 30.92 and 17.11 respectively , the predicted soil temperature for same seasons were 30.83 and 16.94 . (2) for Wadi Yabis measured (32.90, 16.91) predicted (32.72 , 16.94). Deir Alla , measured 32.70, 18.06) . predicted 32.74, 18.23) and so on .. .

These extremely small differences between measured and predicted clearly indicated that claculated equations can be safely used to predict the soil temperature for various months in the zone ranging from 5-60 cm.

Table 5 shows in addition to some climatic date, the measured mean soil temperature at 50 cm depth (summer, winter and annual, designated by 1, 2, 3 and summer , winter (4,5) as defined in the USDA soil taxonomy). Comparing the measured and the predicted equations (table 1-4) indicated t high adequacy of the estimated equations.

The differences between measured air and soil temperature indicate that mean annual mean maximum temperature is higher than soil temperature (at depth of 50 cm) by 3.5 - 4°c while annual soil temperature was higher than annual air temperature by 1.8 - 2 except for Wadi Yabis area (3.4°c). It should be noted here that mean air (for Wadi Yabis station) temperature was calculated for the period 1924 - 1965 is 23.5 (2). If this value is used, then the difference between air and soil temperature becomes 2°c which falls in the range reported for other station. Moreover, no significant difference existed between air temperature computed from 11 years data and the ones computed for the 1927 - 1965 period as reported in the metreological handbook(2). Soil temperature reported here covered a period of 11 years, but available for 4 years in reference No. 2 . Furthermore, small differences were obtained when calculating the average measured soil temperature during the warmest (set 1) or coldest (sets) and the average soil temperature for the summer and winter seasons as defined by the USDA Soil Taxonomy (4) . See table (4) . These differences were as low as .12°c , 3.8°c for Deir Alla station and up to 17°c and ,86°c for Wadi Yabis station .

It is worth noting here that measured differences between, mean air and soil temperature (at the depth of 50 cm) found in this study were approximately 2°c, while the difference was 1 degree for most of the soils in the U.S.A. (4) .

Applying the criterion used to determine the soil temperature regime of the USDA soil classification system (this criterion is based on the mean annual soil temperature, and the difference between mean summer and winter temperature of soils at the depth of 50 cm), the soils in this region would qualify to have hyperthermic temperature regimes.

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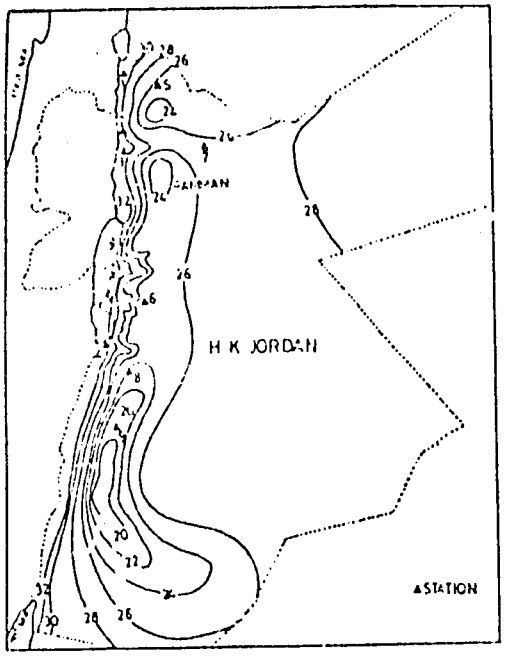

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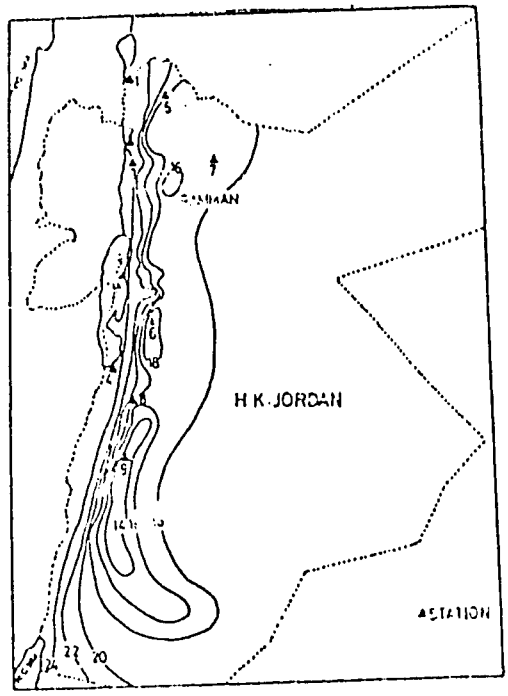

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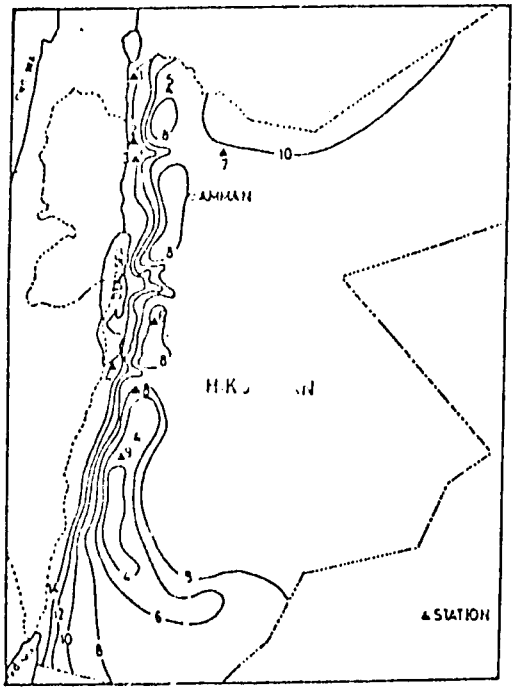

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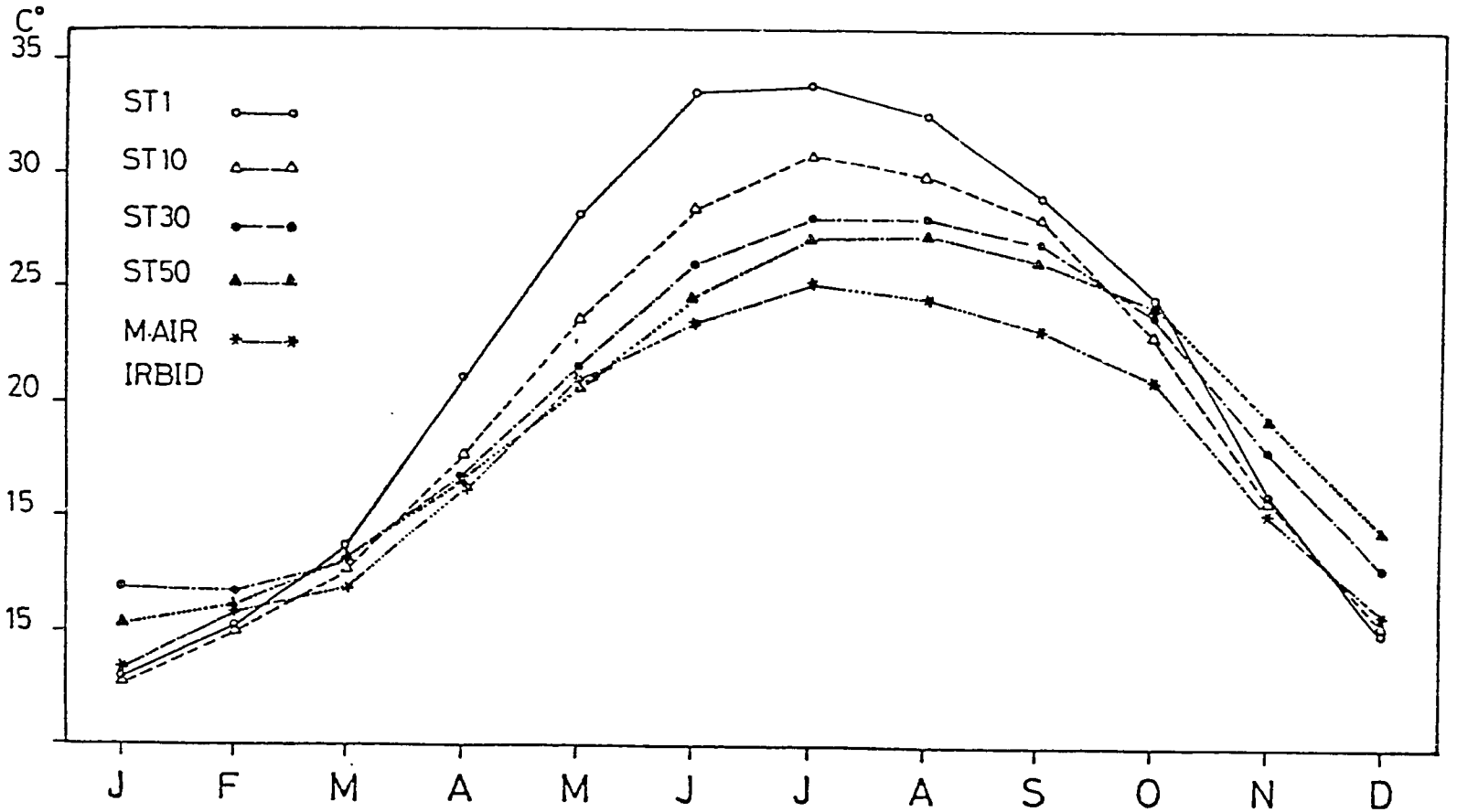

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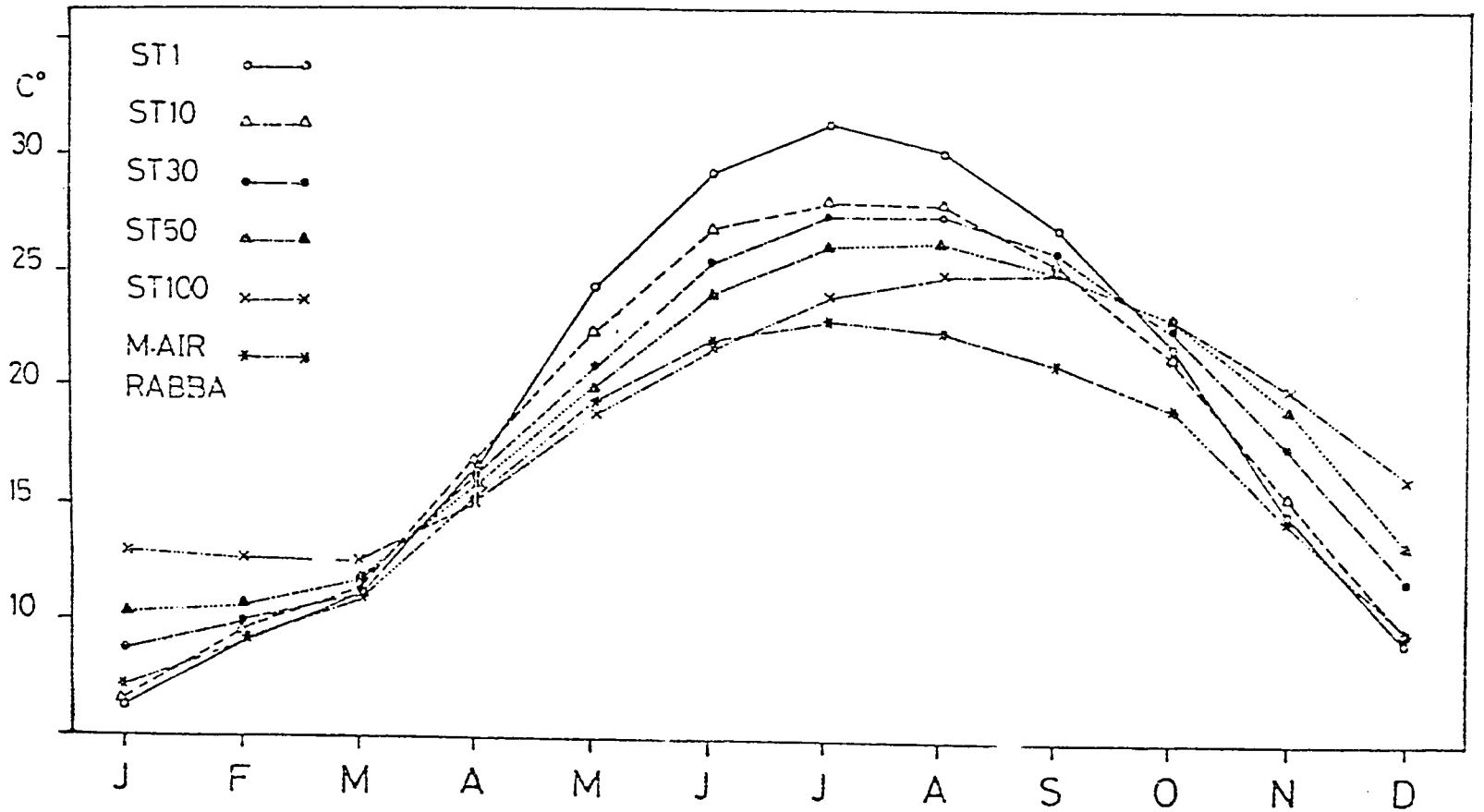
C°
30
25
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ST1
ST10
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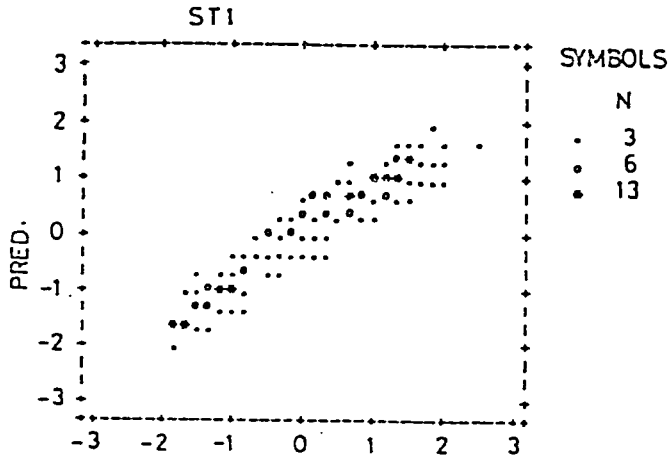
figure_5



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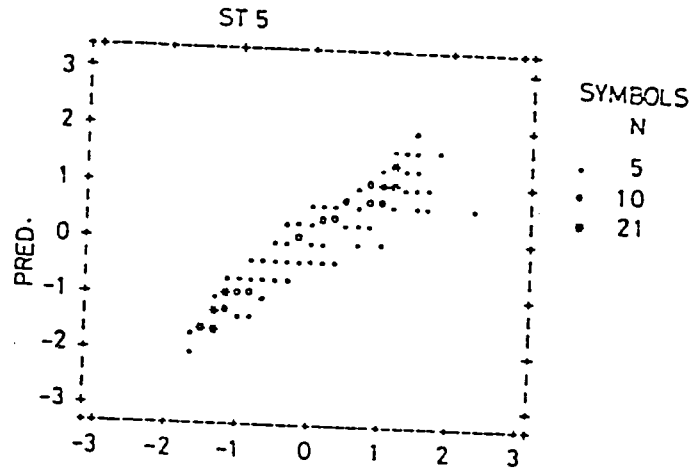

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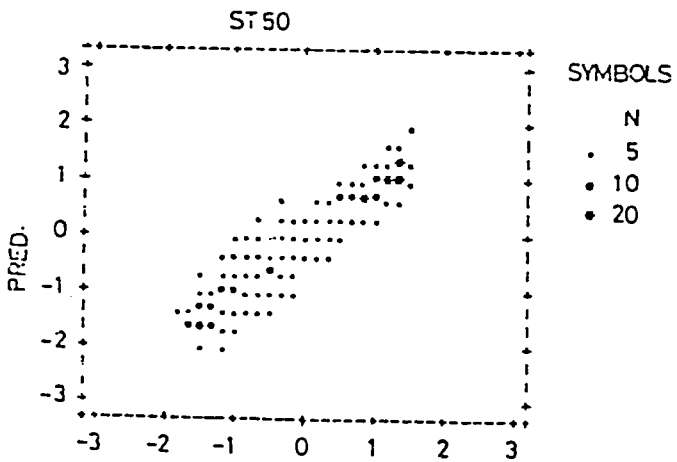

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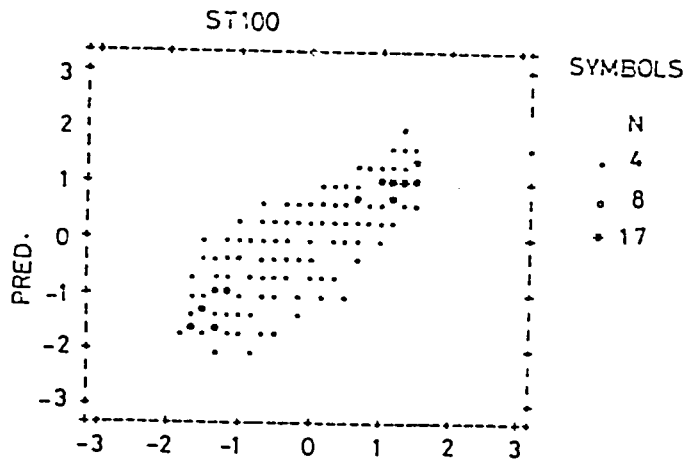

figure_9

TABLE 1 : RELATIONSHIP BETWEEN AIR AND SOIL TEMPERATURE FOR DIFFERENT SOIL DEPTHS FOR EL-BAQURA

ST	c	b	R	Fc/Ft
	MEAN MAXIMUM AIR TEMPERATURE (MAT)			
1-1	24.4	0.76003(3)	.58	12
2-1	- 1.1	0.80	.78	37
3-1	9.8	0.02(2)	.82	100
1-5	12.5	0.02(2)	.76	33
2-5	- 2.4	0.06	.95	220
3-5	6.6	0.02(2)	.97	777
1-10	19.5	0.27003(3)	.74	29
2-10	- 1.4	0.82	.95	205
3-10	7.6	0.02(2)	.95	457
1-20	14.3	0.01(2)	.76	32
2-20	1.3	0.72	.89	99
3-20	9.5	0.02(2)	.94	381
1-30	20.2	0.2400(3)	.73	27
2-30	2.1	0.70	.90	105
3-30	9.3	0.02(2)	.96	027
1-50	17.7	0.01(2)	.50	14
2-50	7.2	0.52	[illegible]	36
3-50	12.3	0.[illegible](2)	[illegible]	[illegible]
1-100	16.7	[illegible]	.48	7
2-100	7.1	0.[illegible]	.44	[illegible]
3-100	[illegible].7	0.[illegible](2)	.83	[illegible]1

Table 1. Cont.

		MEAN AIR TEMPERATURE (MAT)		
1-1	8.2	0.99	.62	15
2-1	.2	1.00	.76	33
3-1	0.6	1.19	.83	107
1-5	-2.0	1.22	.85	61
2-5	-1.6	1.10	.95	248
3-5	-4.8	1.31	.98	1129
1-10	1.2	1.07	.83	54
2-10	- .7	1.05	.95	237
3-10	-2.8	1.20	.96	626
1-20	2.8	0.98	.84	56
2-20	1.9	0.93	.91	114
3-20	1.2	1.07	.95	455
1-30	3.9	0.95	.83	52
2-30	2.5	0.91	.93	143
3-30	-0.2	1.09	.98	959
1-50	7.8	0.78	.71	52
2-50	7.1	0.70	.81	47
3-50	4.4	0.89	.93	330
1-100	11.0	0.59	.58	12
2-100	13.5	0.40	.50	8
3-100	16.5	0.01(3)	.85	132

Table 1. Cont.

	MEAN MINIMUM AIR TEMPERATURE (MMAT)			
1-1	2.9	0.7703(3)	.57	12
2-1	4.6	1.11	.67	20
3-1	4.6	1.34	.81	91
1-5	7.7	1.18	.86	67
2-5	2.8	1.28	.88	66
3-5	0.6	1.50	.97	742
1-10	9.8	1.04	.84	59
2-10	3.3	1.23	.86	87
3-10	2.2	1.37	.95	448
1-20	9.9	0.99	.88	24
2-20	5.3	1.09	.85	25
3-20	4.5	1.23	.94	48
1-30	10.2	0.98	.90	96
2-30	5.6	1.09	.88	84
3-30	4.1	1.26	.97	851
1-50	12.6	0.82	.78	37
2-50	9.2	0.67	.80	43
3-50	7.8	1.03	.94	356
1-100	13.5	0.68	.70	23
2-100	14.2	0.55	.55	10
3-100	12.4	0.72	.56	160

Number of observations used to estimate equation 1, 2 and 3 were 194, 201 and 357 respectively.

Table 2. Relationships between air and soil temperature at different depths for WADI YASIS.

ST	c	b	R	Fc/Ft
	MEAN MAXIMUM TEMPERATURE (MMAT)			
1-1	-20.4	1.66	.84	25
2-1	6.8	0.02(2)	.88	34
3-1	-13.5	1.45	.96	224
1-5	-13.9	1.34	.84	24
2-5	8.0	0.02(2)	.91	49
3-5	- 9.0	1.19	.96	235
1-10	-10.4	1.22	.86	28
2-10	8.5	0.02(2)	.92	53
3-10	- 7.3	1.12	.96	272
1-20	- 6.8	1.10	.86	28
2-20	10.7	0.01(2)	.83	22
3-20	- 0.1	0.09	.87	65
1-30	- 2.5	1.0	.86	29
2-30	10.0	0.02(2)	.88	35
3-30	- 3.8	1.00	.96	224
1-50	2.9	0.81	.77	14
2-50	12.3	0.01(2)	.80	18
3-50	0.1	0.87	.94	160
1-100	20.9	0.26	.40	2
2-100	20.7	0.50(3)	.32	1
3-100	21.1	0.18	.45	5

Table 2. cont.

MEAN AIR TEMPERATURE (MAT)

1-1	-8.9	1.70	.86	28
2-1	-6.3	1.52	.92	58
3-1	-9.1	1.70	.97	366
1-5	-6.6	1.45	.90	41
2-5	-2.1	1.19	.95	102
3-5	-5.6	1.41	.98	559
1-10	-4.3	1.34	.93	63
2-10	-1.5	1.16	.97	137
3-10	-4.0	1.32	.99	826
1-20	-1.5	1.21	.94	71
2-20	10.2	0.03(2)	.87	36
3-20	2.0	1.08	.92	104
1-30	1.9	1.09	.95	92
2-30	0.5	1.09	.95	89
3-30	-1.0	1.18	.99	861
1-50	5.6	0.93	.88	34
2-50	3.8	0.95	.87	32
3-50	2.5	1.04	.97	337
1-100	21.6	0.30	.46	3
2-100	19.8	0.15	.33	1
3-100	21.4	0.22	.48	6

Table 2. cont.

	MEAN MINIMUM AIR TEMPERATURE (MMAT)			
1-1	8.7	1.47	.80	18
2-1	9.6	0.09(2)	.82	21
3-1	8.5	1.86	.96	211
1-5	7.0	1.32	.86	36
2-5	3.4	1.40	.86	29
3-5	2.1	1.55	.97	344
1-10	7.9	1.23	.93	63
2-10	3.7	1.38	.89	35
3-10	3.2	1.46	.98	448
1-20	9.4	1.13	.94	77
2-20	9.4	1.18	.82	20
3-20	7.6	1.21	.92	110
1-30	11.4	1.02	.97	144
2-30	5.0	1.34	.89	40
3-30	5.4	1.31	.95	514
1-50	17.2	0.91	.92	60
2-50	7.4	1.20	.85	25
3-50	8.0	1.16	.97	317
1-100	23.5	0.30	.50	3
2-100	15.8	0.16	.30	1
3-100	12.4	0.25	.50	7

Number of observations used to estimate regression models 1, 2 and 3 were 33, 61 and 165 respectively.

Table 3. Relationships between air and soil temperature at different depths for Deir Alla.

ST	c	b	R	Fc/Ft
	MEAN MAXIMUM AIR TEMPERATURE (MMAT)			
1-1	16.0	0.01(2)	.66	18
2-1	- 3.6	0.96	.99	93
3-1	- 5.5	1.08	.91	242
1-5	- 4.2	1.07	.78	36
2-5	- 4.5	1.00	.95	208
3-5	- 8.2	1.17	.97	759
1-10	13.9	0.01(2)	.86	70
2-10	- 2.4	0.91	.96	278
3-10	8.2	0.02(2)	.98	1204
1-20	16.6	0.01(2)	.81	45
2-20	0.8	0.78	.92	141
3-20	- 2.6	0.95	.97	516
1-30	17.6	0.01(2)	.76	33
2-30	2.5	0.74	.88	89
3-30	- 0.5	0.89	.95	477
1-50	23.6	0.06(2)	.67	19
2-50	6.7	0.53	.80	42
3-50	12.9	0.91	.94	355
1-90	20.2	0.01(2)	.94	17
2-90	.5	0.52	.72	26
3-90	14.0	0.01(2)	.92	250

Table 3. Cont.

1-100	24.1	0.001(3)	.49	9
2-100	13.3	0.36	.53	9
3-100	16.3	0.01(2)	.56	140
1-200	25.3	0.001(3)	.22	1
2-200				
3-200	21.2	0.01(2)	.60	27
		MEAN AIR TEMPERATURE (MAT)		
1-1	23.0	0.001(3)	.63	15
2-1	- 2.9	1.17	.67	77
3-1	- 4.3	1.30	.91	225
1-5	- [illegible].6	1.28	.79	39
2-5	- 3.9	1.23	.93	165
3-5	- 0.1	1.42	.97	755
1-10	-14.2	0.02(3)	.90	97
2-10	- 2.1	1.13	.95	249
3-10	- 5.7	1.34	.98	1395
1-20	0.6	1.08	.91	110
2-20	0.5	1.00	.95	207
3-20	- 2.2	1.16	.98	1437
1-30	1.7	1.04	.88	83
2-30	2.0	0.96	.92	131
3-30	- 0.1	1.09	.97	222

Table 3. Cont.

1-50	6.2	0.87	.82	47
2-50	6.0	0.78	.84	61
3-50	2.6	0.98	.96	627
1-60	5.8	0.86	.82	50
2-60	7.6	0.71	.78	39
3-60	4.3	0.90	.95	454
1-100	7.9	0.76	.70	23
2-100	12.0	0.52	.62	15
3-100	16.2	0.02(2)	.90	209
1-200	13.3	0.50	.47	7
2-200	20.2	0.18	.23	1
3-200	22.1	0.001(3)	.67	39
	MEAN MINIMUM AIR TEMPERATURE (MNAT)			
1-1	0.8	0.76	.46	6
2-1	0.7	1.32	.79	40
3-1	- 0.2	1.50	.86	137
1-5	13.2	0.97	.64	17
2-5	- 0.3	1.40	.86	66
3-5	- 0.2	1.67	.94	335
1-10	11.8	0.99	.74	29
2-10	1.0	1.31	.89	92
3-10	- 3.1	1.59	.95	467

Table 3. Cont.

1-20	12.1	0.90	.82	48
2-20	2.6	1.21	.92	135
3-20	0.7	1.39	.96	640
1-30	12.3	0.89	.82	47
2-30	3.6	1.18	.91	119
3-30	2.4	1.32	.96	498
1-50	14.0	0.79	.80	42
2-50	6.9	0.99	.67	74
3-50	4.7	1.19	.95	543
1-60	12.8	0.82	.84	59
2-60	7.9	0.94	.84	56
3-60	6.1	1.11	.95	500
1-100	12.8	0.78	.78	36
2-100	11.3	0.76	.72	26
3-100	9.4	0.92	.92	273
1-200	14.2	0.62	.63	15
2-200	20.9	0.01(2)	.40	4
3-200	15.8	0.50	.73	56

Number of observations used to estimate equation number 1, 2 and 3 were 194, 199 and 395 respectively.

Table 4. Relationships between air and soil temperature at different depths for Gohor Safi.

ST	c	b	R	Fc/Ft
	MEAN MAXIMUM AIR TEMPERATURE (MMAT)			
1-1	2.7	0.88	.90	33
2-1	- 4.2	1.01	.94	163
3-1	- 0.8	0.92	.87	123
1-5	- 7.0	1.15	.91	92
2-5	- 6.8	1.10	.98	606
3-5	- 8.2	1.17	.98	658
1-10	- 0.01	0.94	.85	48
2-10	- 4.9	1.05	.96	219
3-10	- 5.0	1.06	.97	633
1-20	2.7	0.85	.89	72
2-20	- 4.3	1.02	.98	546
3-20	- 4.5	1.04	.99	1384
1-30	8.5	0.70	.80	33
2-30	- 1.8	0.95	.96	211
3-30	0.6	0.89	.92	203
1-50	19.0	0.01(2)	.56	9
2-50	- 1.9	0.94	.90	81
3-50	0.1	0.86	.90	172
1-100	16.9	0.38	.55	8
2-100	17.0	0.01(2)	.94	137
3-100	18.1	0.01(2)	.88	139

Table 4. Cont.

	MEAN AIR TEMPERATURE (MAT)			
1-1	20.3	0.02(2)	.75	24
2-1	1.8	0.98	.83	44
3-1	3.7	0.97	.87	123
1-5	- 3.3	1.27	.87	57
2-5	- 3.5	1.24	.95	183
3-5	- 2.4	1.21	.97	578
1-10	2.9	1.04	.80	35
2-10	- 0.7	1.12	.95	171
3-10	0.2	1.10	.96	488
1-20	3.6	1.00	.90	70
2-20	0.6	1.06	.96	217
3-20	0.8	1.09	.99	1362
1-30	21.4	0.01(2)	.82	38
2-30	4.8	0.97	.89	74
3-30	4.5	0.94	.93	234
1-50	22.6	0.001(3)	.61	11
2-50	5.7	0.91	.72	21
3-50	3.9	0.92	.91	197
1-100	25.4	0.0002(3)	.64	13
2-100	13.6	0.46	.64	14
3-100	22.4	0.01(2)	.88	137

Table 4. Cont.

		MEAN MINIMUM AIR TEMPERATURE (MMAT)		
1-1	25.3	0.02(2)	.60	10
2-1	19.9	0.07	.81	36
3-1	8.6	1.01 (0.94006(3))	.85	51
1-5	2.9	1.01	.71	26
2-5	19.6	0.07	.78	30
3-5	2.3	1.35 (-.13006(3))	.95	171
1-10	13.0	0.90	.66	15
2-10	20.1	0.07	.81	36
3-10	5.2	1.19 (-.11005(3))	.94	137
1-20	11.2	0.94	.81	35
2-20	20.1	0.07	.83	42
3-20	5.2	1.15 (-.11003(3))	.97	234
1-30	24.6	0.02(2)	.74	23
2-30	20.8	0.07	.85	52
3-30	5.3	0.78 (-.92006(3))	.91	96
1-50	20.5	0.02(2)	.61	11
2-50	20.5	0.07	.81	36
3-50	8.9	0.94 (0.88006(3))	.90	82
1-100	21.8	0.01(2)	.68	19
2-100	21.8	0.07	.91	93
3-100	15.2	0.01 (-.54006(3))	.89	78

Number of observations used to estimate eruption number 1, 2 and 3 were 155, 100 and 315 respectively.

Table 5. Metereological data for El-bacuara, Wadi Yabis, Deir Alla and Ghor Safi.

	Elevation	latitate		longlitude		Precip	Air Temperature M.MAX	M.Min	M.Air T.	M.ST 50
	m					mm/yr	C°			
1- El-baquara	-197	32	37	35	37	400	1- 34.54	20.94	27.93	29.66
							2- 22.49	11.17	16.65	19.33
							3- [illegible]	15.85	22.29	24.20
							4- 36.36	22.36	29.52	30.92
							5- 19.33	9.46	14.05	17.11
2- Wadi Yabis	-200	32	24	35	35	300	1- 35.22	20.04	27.61	31.35
							2- 21.87	9.32	16.69	18.81
							3- 29.08	15.10	22.12	25.53
							4- 36.69	21.77	29.23	32.90
							5- 19.20	9.28	13.83	16.91
3- Deir Alla	-224	32	12	35	37	250	1- 36.05	20.01	29.05	31.36
							2- 23.05	13.44	18.22	20.22
							3- 29.52	17.64	23.57	25.65
							4- 37.92	23.21	30.51	30.70
							5- 19.79	11.56	15.68	18.06
4- Ghor Safi	-387	31	.0	35	30	100	1- 36.99	24.28	30.64	32.04
							2- 24.86	13.85	19.42	21.52
							3- 30.85	18.98	24.95	26.79
							4- 39.13	25.56	32.38	33.40
							5- 21.81	11.53	16.63	18.94

1, 2 and 3 represent data for set, 1, 2 and 3 respectively, 4 and 5. represent average. temperature for summer and winter defined in USDA soil taxonomy respectively .

Table 1. Relationships between air and soil temperature at different depths for Irbid.

ST*	c**	b	R	Fc/Ft
	MEAN MAXIMUM AIR TEMPERATURE (MMAT)			
1-1	-5.1	1.23	.70	23
2-1	-4.6	1.06	.92	126
3-1	-8.6	1.33	.95	484
1-5	-8.2	1.25	.82	48
2-5	-2.2	0.87	.92	128
3-5	4.6	0.03(2)	.97	701
1-10	-4.7	1.11	.78	38
2-10	-2.2	0.88	.92	128
3-10	-6.2	1.15	.96	614
1-20	-1.1	0.96	.80	42
2-20	-3.4	0.80	.92	139
3-20	-4.1	1.04	.97	733
1-30	1.7	0.64	.75	31
2-30	2.9	0.65	.86	71
3-30	8.2	0.02(2)	.94	376
1-50	5.2	0.69	.69	22
2-50	5.5	0.54	.76	35
3-50	7.2	0.77	.92	264

* represent warm months (May-October) 2 represent cold months (November-April). 3 represents (Mean annual). 1, 5, 10, 50, 100 are soil depths.

**Soil Temp (ST) = c + b (air temp)^x, were c is the intencept, b regression coefficient and x degree of polynomial. R = Multiple correlation .

Table 1. Cont.

		MEAN AIR TEMPERATURE (MAT)		
1-1	2.5	1.20	.66	19
2-1	-6.7	1.83 (-.001(3))	.51	62
3-1	-3.6	1.44	.93	316
1-5	-1.6	1.27	.81	44
2-5	-4.4	1.55 (-.86D03(3))	.93	90
3-5	-2.9	1.30	.95	440
1-10	0.9	1.15	.78	38
2-10	-4.4	1.56 (-.67D03(3))	.94	89
3-10	-2.0	1.25	.95	417
1-20	3.2	1.01	.62	48
2-20	-2.5	1.43 (-.81D03(3))	.95	116
3-20	-0.3	1.13	.95	484
1-30	4.9	0.90	.79	39
2-30	1.2	1.16 (-.66D03(3))	.89	42
3-30	2.6	0.98	.92	282
1-50	7.6	0.75	.73	28
2-50	3.6	1.00 (-.50D03(3))	.80	22
3-50	5.0	0.84	.91	223

Table 1. Cont.

	MEAN MINIMUM AIR TEMPERATURE (MMAT)			
1-1	19.4	0.04(2)	.64	17
2-1	2.1	1.49	.87	77
3-1	1.3	1.65	.94	394
1-5	5.1	1.31	.83	52
2-5	2.8	1.28	.91	125
3-5	1.4	1.50	.97	786
1-10	6.8	1.20	.81	47
2-10	2.9	1.30	.92	128
3-10	2.1	1.45	.97	713
1-20	7.8	1.08	.87	78
2-20	4.2	1.19	.93	166
3-20	3.4	1.32	.98	1069
1-30	8.5	1.00	.87	74
2-30	6.7	0.94	.85	65
3-30	5.8	1.14	.95	425
1-50	10.0	0.87	.84	59
2-50	8.5	0.82	.78	39
3-50	7.7	0.98	.94	341

Number of observations used to estimate equation 1, 2 and 3 were 156, 272 and 400 respectively.

Table 2. Relationships between air and soil temperature at different depths for Rebba.

ST	c	b	R	Fc/Ft
	MEAN MAXIMUM AIR TEMPERATURE (MMAT)			
1-1	0.6	0.98	.72	21
2-1	6.1	0.02(2)	.83	42
3-1	- 0.7	0.93	.84	92
1-5	- 1.6	1.04	.71	19
2-5	- 2.1	0.92	.92	105
3-5	- 6.2	1.18	.95	366
1-10	- 1.1	0.97	.80	34
2-10	- 1.5	0.85	.93	128
3-10	- 4.7	1.09	.97	545
1-20	4.2	0.75	.77	28
2-20	0.6	0.73	.90	86
3-20	- 1.8	0.94	.94	319
1-30	6.4	0.69	.62	12
2-30	3.0	0.63	.84	45
3-30	0.1	0.86	.91	177
1-50	6.7	0.64	.70	18
2-50	4.2	0.59	.80	33
3-50	1.4	0.81	.93	253
1-100	11.3	0.42	.46	5
2-100	12.3	0.01(2)	.54	8
3-100	7.9	0.50	.76	60

Table 2. Cont.

	MEAN AIR TEMPERATURE (MAT)			
1-1	4.5	1.06	.73	22
2-1	1.6	0.91	.84	46
3-1	1.4	1.09	.85	98
1-5	3.2	1.11	.70	18
2-5	- 1.0	1.13	.93	131
3-5	- 3.3	1.38	.95	386
1-10	3.0	1.06	.80	34
2-10	- .1	1.04	.95	168
3-10	- 2.2	1.27	.97	695
1-20	7.1	0.82	.79	31
2-20	1.8	0.91	.92	115
3-20	0.4	1.10	.95	361
1-30	8.0	0.80	.67	16
2-30	3.70	0.79	.86	55
3-30	2.04	1.03	.92	201
1-50	8.1	0.75	.76	27
2-50	5.1	0.74	.82	41
3-50	3.2	0.96	.94	306
1-100	11.6	0.53	.53	7
2-100	12.6	0.01	.57	9
3-100	8.8	0.60	.80	68

Table 2. Cont.

	MEAN MINIMUM AIR TEMPERATURE (MMAT)			
1-1	10.9	1.06	.69	18
2-1	4.4	1.06	.82	38
3-1	4.8	1.30	.84	56
1-5	10.6	1.07	.64	13
2-5	2.6	1.31	.90	19
3-5	1.2	1.62	.94	39
1-10	9.5	1.04	.75	24
2-10	3.2	1.22	.92	106
3-10	1.9	1.49	.96	436
1-20	11.8	0.83	.76	25
2-20	4.7	1.06	.90	78
3-20	3.9	1.29	.94	291
1-30	12.0	0.86	.68	17
2-30	6.2	0.92	.84	44
3-30	5.3	1.22	.91	154
1-50	11.4	0.82	.80	33
2-50	7.3	0.88	.81	37
3-50	6.2	1.13	.94	286
1-100	13.4	0.61	.58	10
2-100	11.4	0.49	.57	9
3-100	10.6	0.73	.81	75

Number of observation used to estimate equation 1, 2 and 3 were 116, 198 and 316 respectively.

Table 3. Metereological data for Irbid and Rabba Station.

Station	Eleva	Latitude	longitude	Precip	Air Temperaure			soil temperature at 50 cm	
					M. Max	M.Min.	Mean	Measured	predi-cted**
	m			mm/yr	C°				
5- Irbid	618	32° 33'	35° 51'	450	*1- 28.84	17.25	23.12	25.08	24.94
					2- 16.84	7.49	12.29	14.59	15.42
					3- 22.76	12.30	17.63	19.76	19.81
					4- 30.16	18.65	24.44	26.39	25.93
					5- 13.90	5.66	10.06	12.74	13.19
6- Rabba	920	31° 16'	35° 16'	300	1- 27.30	15.34	21.32	24.14	24.09
					2- 15.59	6.94	11.23	13.49	13.41
					3- 21.41	11.21	16.25	18.73	18.80
					4- 22.79	16.57	22.70	25.48	25.13
					5- 12.67	5.16	8.86	11.53	11.66

* 1, 2, and 3 represent average air temperature for set 1, 2,3. 4 and 5 represent average air temperature for summer and winter defined in the USDA soil taxonomy,respectively .

** predicted from the estimated equations in tabel 1 and 2 (for mean air temperature).

SOILS OF JORDAN

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****

INTRODUCTION :

Soils of Jordan were studied by different people of organizations. Terms and purposes were also different . Forestry Dept. of Moa. invited FAO expert Moorman (1955-1957) . Moorman classified soils of Jordan according to 1938 US Soil Taxonomy system . A general soil map and capability groups of soils were prepared .

Early in the sixties Clawson and others studied our soils through a general study on soils of the middle east. System of 1938 also was used.

The first detailed soil survey operations were in Baqa valley in late sixties, B.West and his Jordanian counterparts mapped soils of the valley. West classified these soils according to the 7nth approximation . After 1970, the detailed work was extended to Karak destrict (about 80,000 D.detailed), and Irbid (25,000 detailed, and about 700,000 D semi-detailed) , through a cooperation between FAO and MAO. Differentiation of soils was by using an established local mapping system (soil legend). This system also put in use by the Germans and their counterparts in the survey of Zerka river valley (1982). The USDA Soil Taxonomy system was used in classifying the major soil series and new types encountered .

Bonofica, an Italian company, (1973), mapped about 20,000 D of Disa basin in detail. System of 1983 was used.

A local consultant engineering company, studied soils of Jordan valley, using certain soil criterias such as texture, salinity...etc.

In 1979, a reconnaissance survey on Balqa areas are completed by the local soil survey staff.

Recent studies by ACSAD and MOA, were in Hamad basin. Soils of the area were mapped and classified according to USADA Taxonomy System.

SOIL FORMING FACTORS

The most important soil forming factors working on Jordan soils are climate, parent materials, and relief . These factors in addition to the biotic factors will be discussed briefly.

1- CLIMATE : According to Long (1957), Jordan has the following bioclimatic zones :

sub-humid , semi- arid , arid cool and warm varieties, and saharian cool and warm varieties . These terms will be discussed in another paper about cliamte of Jordan.

Recent calculations on selected locations, indicate a xeric soil moisture and thermic temperature regimes prevailing in the rainfed areas and mountains. Torric soil moisture and hyperthermic soil temperature regimes are prevailing in Jordan valley and the southern regimes of the eastern part of the country. Meanwhile the soil moisture and temperature regimes of the eastern part of Jordan are aridic and thermic respectively.

Where rainfall is relatively higher, the chemical weathering is more pronounced. On the other hand, top of the mountains and on slopes, water for chemical weathering is limited , therefore, the soil profiles are undeveloped. The amount of precipitation, affected the mineralogy, the salinity, and the lime content and depth of the clacic horizon in soils. As mentioned, limited leaching in desert has an effect on the formation of the sub-surface horizones. The salic horizon is formed on or near the surface, where water table is shallow.

2-PARENT MATERIALS :

The following combinations are recognized in Jordan :

Cherty limestone, cherty limestone associated with basalt, limestone-marle and sandstone, sandstone, sandstone and shales, and granite. Limestone and basalt produced heavy textured soils with moderate to deep profiles. Meanwhile soil derived from sandstone and granite in the south are sandy . Where sandstone and limestone exist together both affected the soil properties. Richness in soluble salts associated with limited leaching, resulted in the formation of sub-surface horizons in the desert. Calcic, gipsic, and salic horizons are common in soils of the Jordanian desert.

3-RELIEFS :

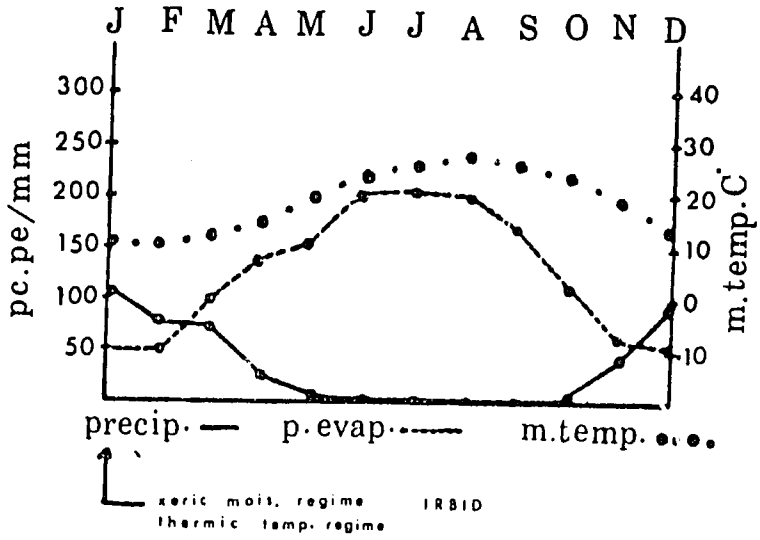
This factor plays a role through its effect on the soil moisture condition or erosion cycle . Mature or well developed soils are mainly recognized on plains, meanwhile young or shallow soils are on slopes and basins or valleys.

4-THE BIOTIC FACTOR :

Man is the most destructive factor. His effect is clear through the severe excavations for roads and buildings. Also he affected the cycle when he cultivated the land and cut trees of the forest and over grazed the range areas. The soil profile of large areas in the desert is destroyed by his vehicle wheels .

Earthwarm costs are a soil criteria of some of the Jordanian soils.

Vegetation have a great influence on soils of mountains. The organic horizon would not exist without a dens plant cover. On the other hand, a light plant cover in the plains or desert resulted in a low content of soil organic matter.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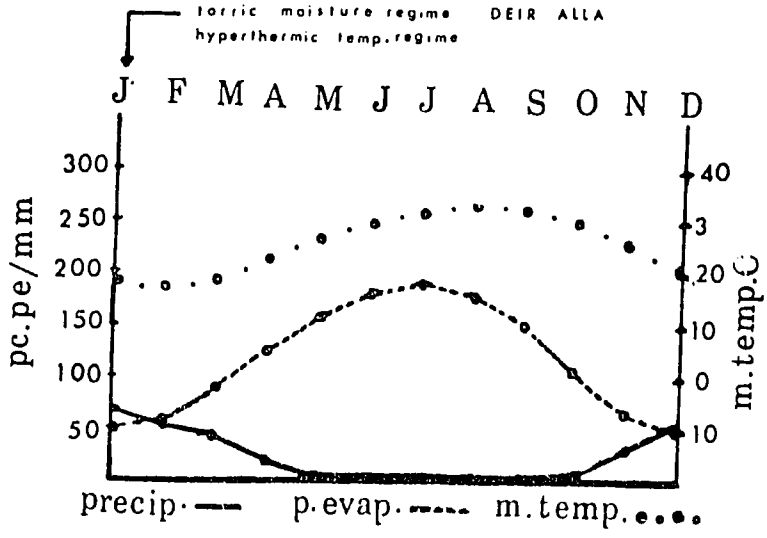
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In general speaking, the soil type in Jordan is a function of precipitation, parent material, reliefs, and vegetation. This is the rule in soil formation.

GENERAL CHARACTERISTICS OF JORDAN SOILS :

Most of Jordan soils have a high clay content in the subsoil, and relatively lower content on the surface. Meanwhile the sandy soils in the south have relatively higher clay content in the surface horizon, rather than the sub-soil .

Lime content increases with depth and in the east direction to the desert . A slight increase in lime content in the surface layer is due to recharge by dust. Soils in the rainfed areas are none to slightly clacareous, meanwhile the other areas are calcareous or very calcareous .

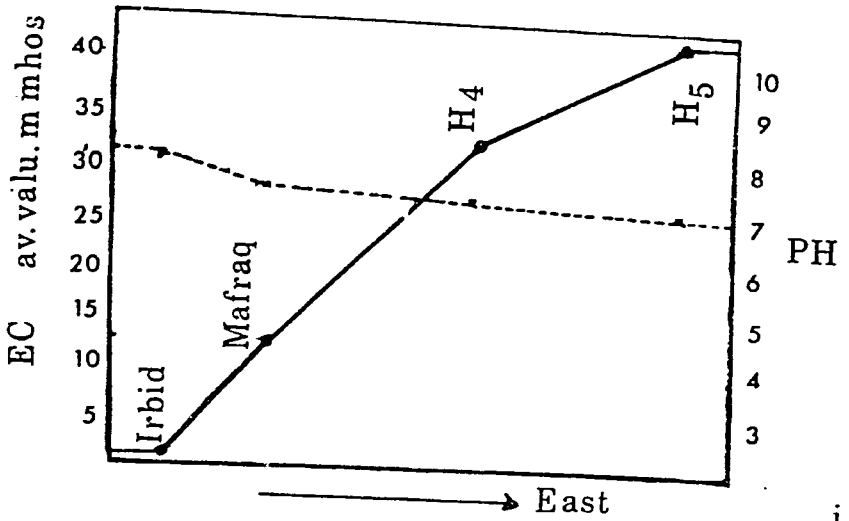
Salinity increases in the east direction. In Jordan valley the increase is in the south direction to the Dead Sea. Soils in rainfed areas and north of Jordan valley are none saline. On the other hand soils of the desert have a very high salts content.

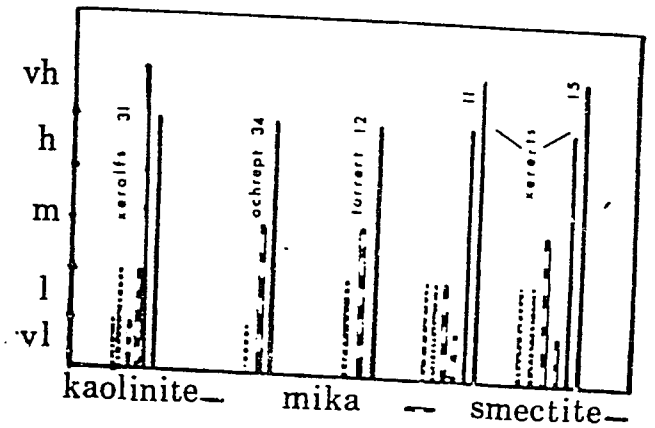
Most of Jordan soils are slightly alkaline . There is a slight decrease in PH values in the east direction to the desert. This behaviour might be due to the salts effect.

Organic matter content in general is low. Maximum values occur on the surface, and decrease with depth. Uncultivated lands have higher content rather than cultivated lands do.

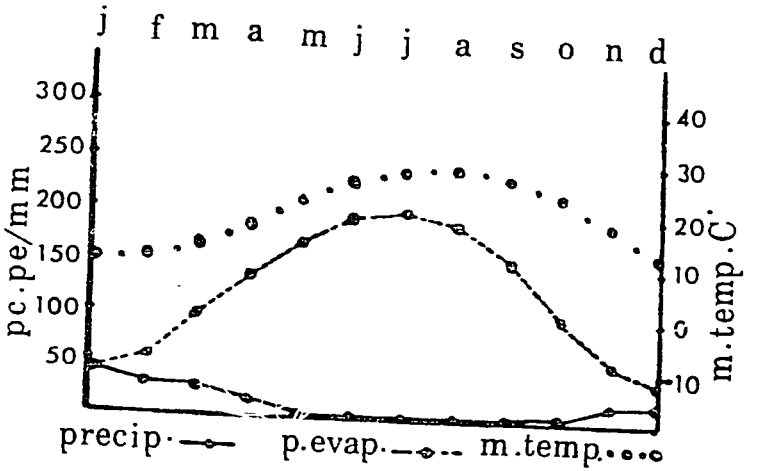
Available P is very low in the cultivated land and becomes low to moderate in the uncultivated land and the desert. On the other hand all samples gave adequate levels of available K except soils derived from sandstone.

CEC values are high to very high in the rainfed areas (more than 25 mq/100 gr soil) . Other areas have moderate CEC values (less than 25 meq/100gr soil) . Changes in values are due to clay content and type of clay in the soil. sandy samples show low values .



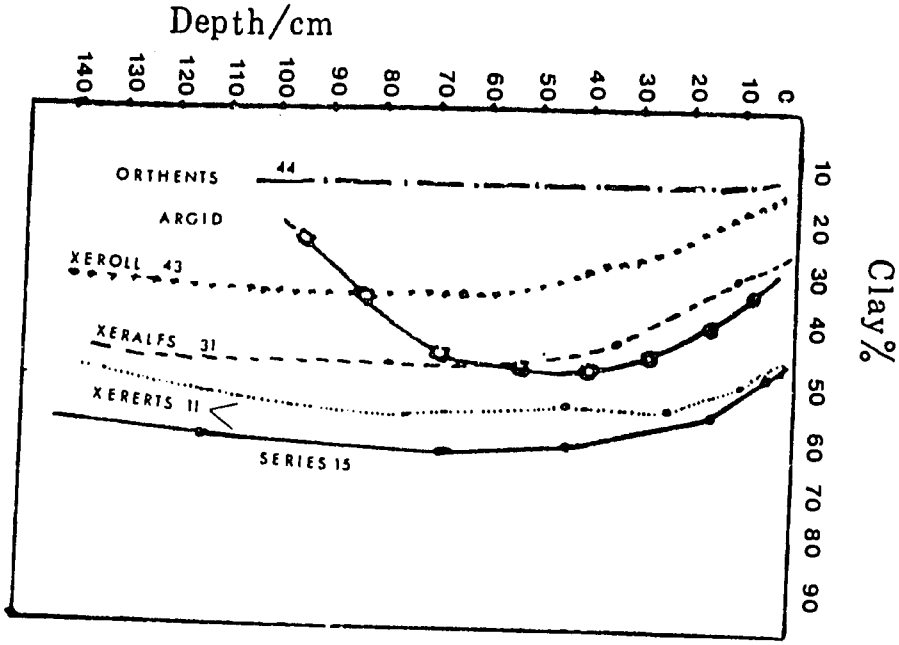


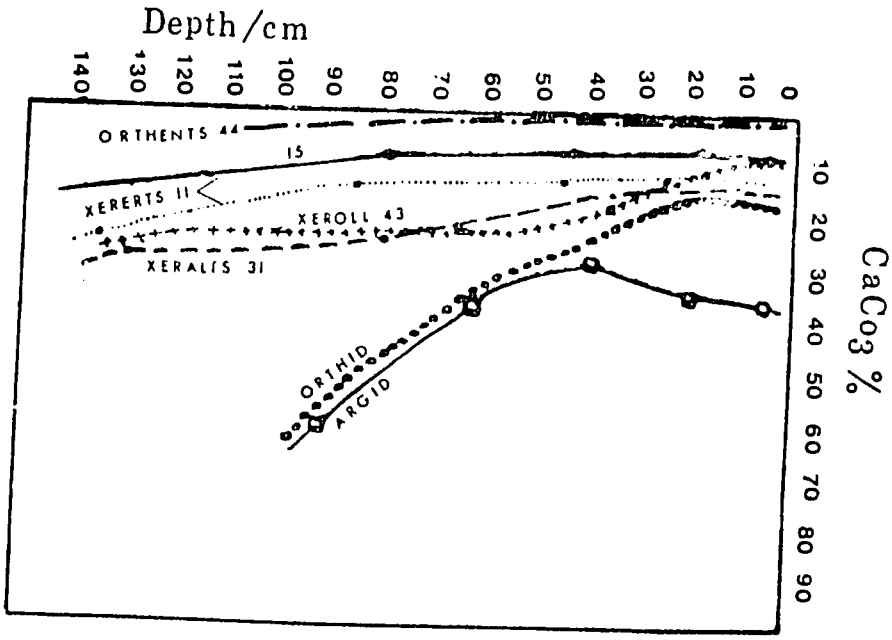
MINERAL ABUNDANCE IN THE CLAYS OF SOME JORDAN SOILS

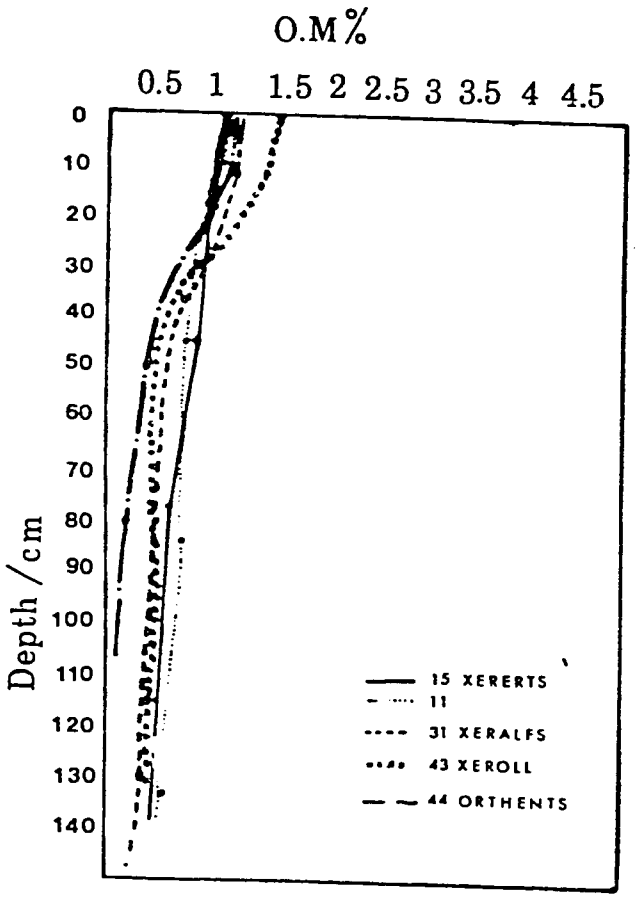


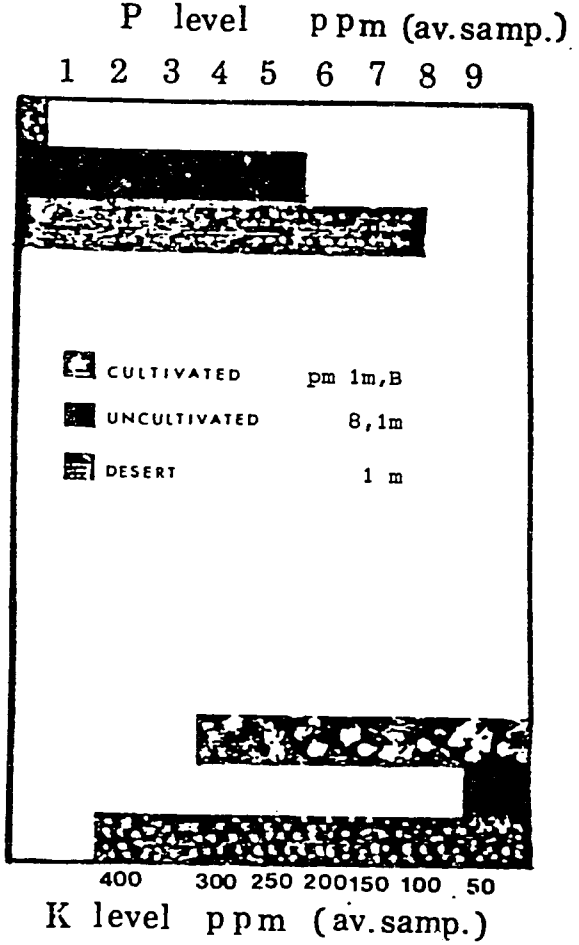
ARIDIC MOIS. REGIME W. DHULEIL

THERMIC TEMPERATURE REGIME


Depth/cm
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
ORTHENTS 44
ARGID
XEROLL 43
XERALFS 31
XERERTS 11
SERIES 15
10 20 30 40 50 60 70 80 90
Clay%


Depth/cm
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
ORTHENTS 44
15
XERERTS 11
XEROLL 43
XERALFS 31
ORTHID
ARGID
10 20 30 40 50 60 70 80 90
CaCo3 %


O.M%
0.5 1 1.5 2 2.5 3 3.5 4 4.5
Depth /cm
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
15 XERERTS
11
31 XERALFS
43 XEROLL
44 ORTHENTS


P level ppm (av.samp.)
1 2 3 4 5 6 7 8 9
CULTIVATED pm 1m,B
UNCULTIVATED 8,1m
DESERT 1 m
400 300 250 200150 100 50
K level ppm (av.samp.)

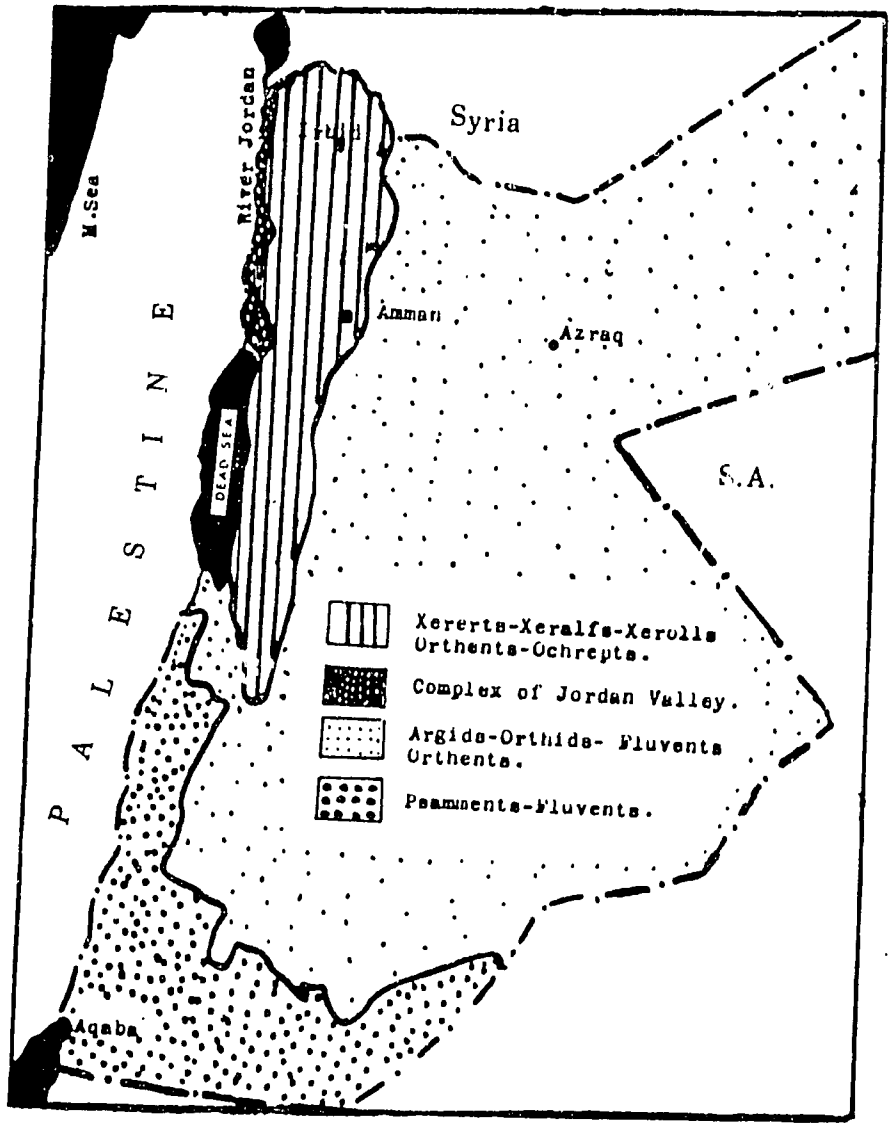
Mineralogical studies on clays show montmorillonite is dominating in the rainfed areas. Mica occurs in moderate amounts , meanwhile kaolinite is reported in small amounts . Soils of other areas have mixed mineralogy (Mt,K,Mi,Ca) . In some locations sepiolite palygorskite, and quartizite are reported.

Finally, colours of Jordan soils range from reddish brown to yellowish brown.

SOIL MAP OF JORDAN

The only published soil map is that prepared by Moorman in 1959 So far there is no attempt to assemble or re-evaluate all previous activities, in order to establish a general soil map in recent time .

Based on all published soil maps of different scales and available data or knowledge about our soils, the following schematic soil map is prepared. This amp should be considered only as tentative . Soil groups at sub-order level using USDA Soil Taxonomy is shown .



Schematic Soil map for Jordan (tentative)

APPENDIX

DESCRIPTION OF SOIL SERIES

Series 11 :

Red clayey soils which form moderately wide cracks in the dry season, and which are developed on hard limestone associated with small amounts of chert.

Series 12 :

Brown, clayey soils which form moderately wide cracks in the dry season , and which are developed on limestone associated with small amounts of chert.

Series 15 :

Red clayey soils which form moderately wide cracks in the dry season , and which are developed on limestone associated with Basalt .

Series 13 :

Red gravelly clay soils which form moderately wide cracks in the dry season and which are developed from hard limestone associated with small amounts of chert.

Series 31 :

Red clayey soil with good structure and developed on hard limestone associated with small amounts of chert.

Series 32 :

Brown clayey soil with moderately good structure and developed on limestone associated with variable amounts of chert.

Unit 93 :

Rocky land with more than 50% of the area covered by outcropping bedrock of hard limestone and by basalt boulders or bedrock .

Series 55 :

Brown silty soil with moderately tendency to form surface crust and developed

on limestone associated with variable amounts of chert.

Series 34 :

Yellowish brown silty soil with moderate tendency to form surface crust and developed on limestone associated with variable amount of chert.

Series 37 :

Red or brown gravelly clay soils with good structure and developed on hard limestone associated with small amounts of chert.

Series 41 :

Brown clayey soils with strong structure and tendency to form crust and derived from soft limestone and sandstone .

Series 42 :

Very dark brown sandy loams over dark brown clay loams with moderate structure and tendency to form surface crust and developed on limestone, marle and sandstone .

Series 44 :

Brown sandy soils not calcareous, with weak structure or massive developed on sandstone .

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LANDUSE IN JORDAN

By: Bakr H. A. QUDAH

****

INTRODUCTION :

The purpose of this report is to attach the landuse map of Jordan and to give a brief analysis of the present patterns of landuse. A general block-diagram along with other block diagrams will be presented so as to explain the main physiographic units and their main landuse pattern.

Agriculture, still plays an important role in the economy of Jordan. It contributes on an average of 30% of exports and one third of total employment (1)

The effect of human activity on landuse can be clearly seen on the landuse map where landuse zones are shown according to the vegetation and type of cultivation . Such zones, formed naturally or by human activity are those of forest and scrub on one hand and cereals, vines, irrigated zones etc.. on the other.

The landuse pattern goes with similar patterns as topography and climate , such as forest lands occupy the higher places, cereals are cultivated on the gently sloping land, furthermore, grazing is concentrated in the east where rainfall is limited.

Agriculture contributes 8.5% to the gross domestic production irrgated areas which constitute only 6% of the cultivated land contribute 58% of the total crop production value. Irrigation becomes more and more important as time goes on and a substantial extension of the land under

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1) Landuse capability planning study - Jordan/March 1983

irrigation is expected in the near future, although the available irrigation water from surface and underground is limited.

The figures presented in this report concerning the categories were obtained by consulting various reports whereas statistics on the agriculture crops were obtained from various sources, such as recent reports and personal contacts with officers from the Ministry of Agriculture.

General Features :

The Hashemite Kingdom of Jordan is located between latitudes 29°-33° north and longitudes 35°-39° east, Fig(1). The Jordan river crosses the country from north to south ending in the Dead Sea and dividing the country into two sections, i.e. the West Bank and East Bank .

The general area of the East Bank is nearly (9.26) million ha.(Fig2). This area includes the capital Amman, Irbid, Zarka, Madaba and Salt.

The population density decreases generally from west to east and from north to south in accordance with the decline in amount of rainfall.

Climate :

Jordan has a Mediterranean climate characterized by predominant winter rainfall, while the summer is dry and hot. The total precipitation varies greatly from year to year as well as in its distribution during the season, Fig(3), (4) . The rainy season extends from October till May, being heaviest between November and March .

Relative humidity may reach its highest level of (72%) during winter months (December-Fenruary) then it gradually decreases during spring untill it reaches its lowest limits between (50-42%) during summer.

The winter winds are mainly SW with average speeds of 20-30Km/hr. Occasional SW or westerly gales are experienced . The summer winds are mainly from a SW direction. Hot, dust-laden winds from the east and south, the so called " Kamisinic " occur during early summer.

Jordan Climatological Handbook (1968)

JORDAN

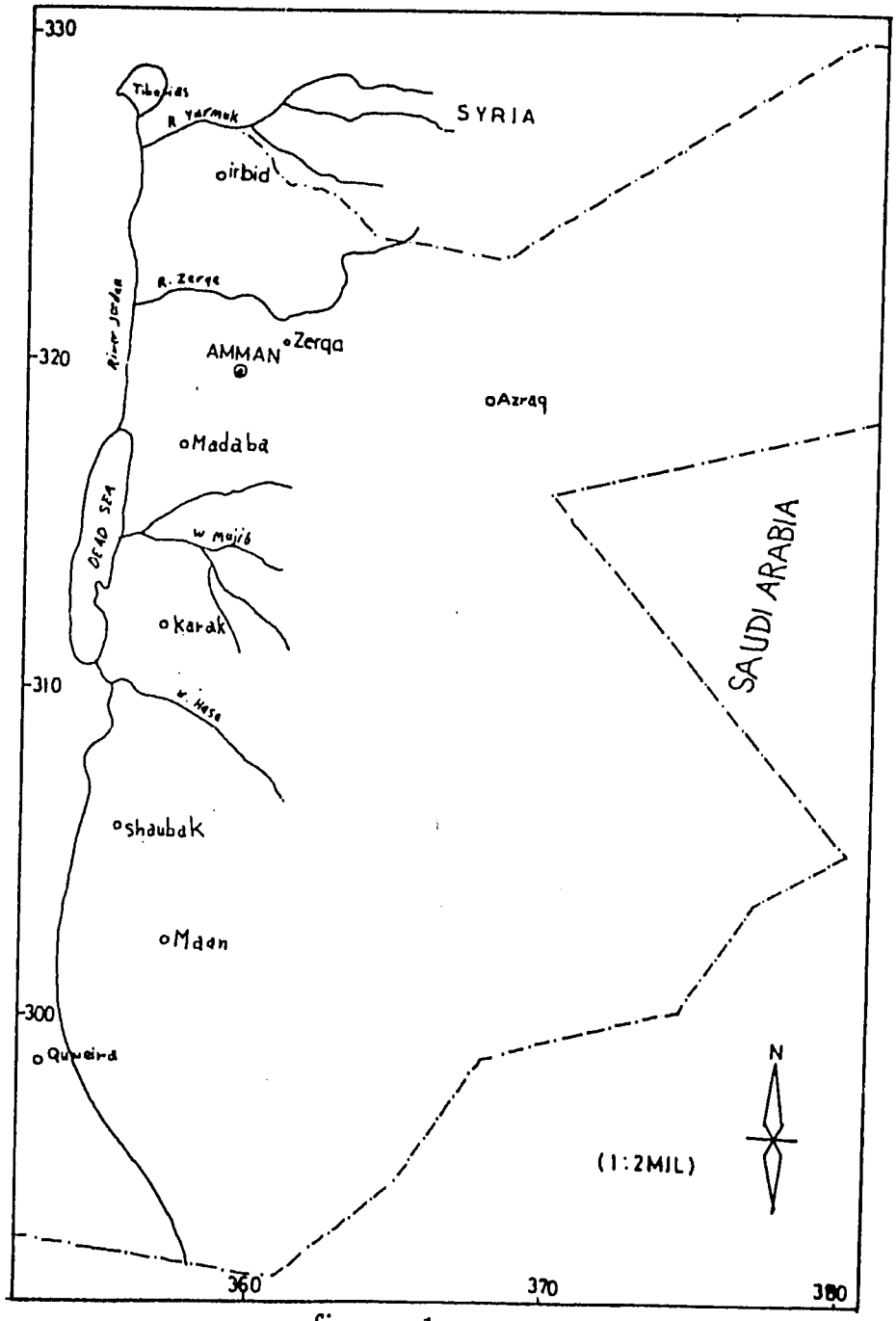


figure_1

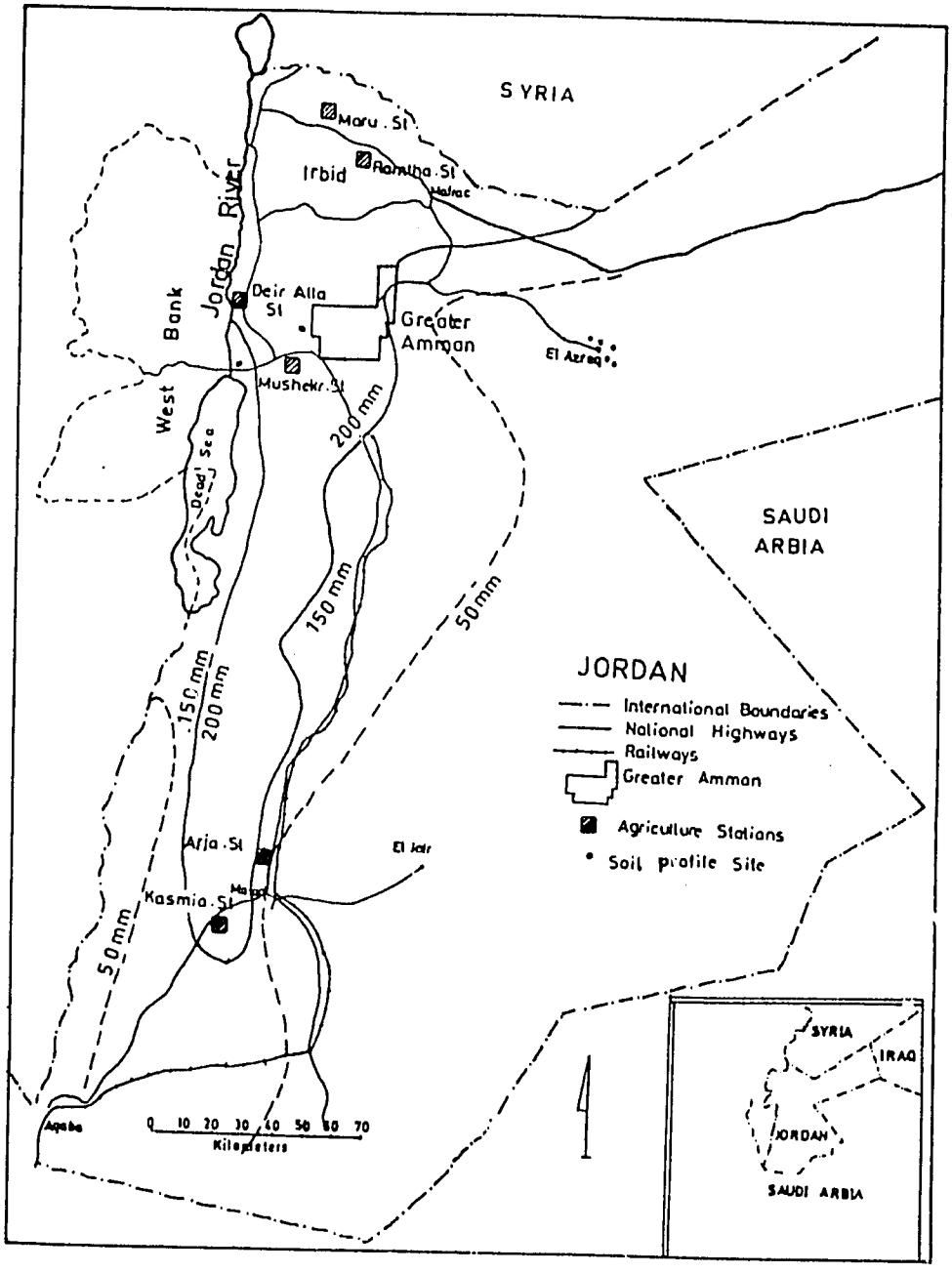
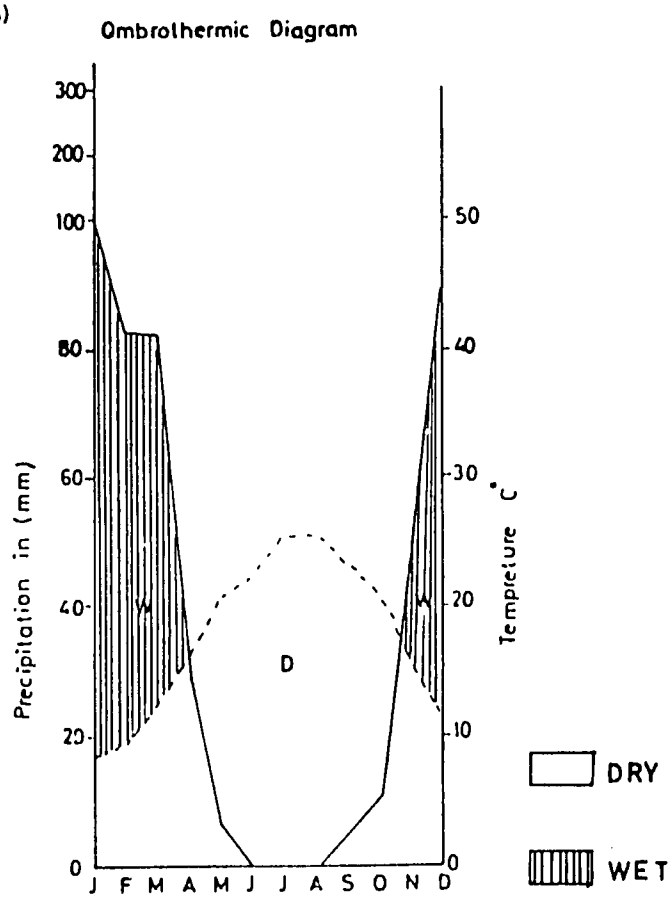

SYRIA
Maru . St
Irbid
Ramtha . St
Jordan River
Deir Alla St
Greater Amman
El Azraq
West Bank
Mushekr. St
Dead Sea
200 mm
150 mm
50 mm
SAUDI ARBIA
JORDAN
International Boundaries
National Highways
Railways
Greater Amman
Agriculture Stations
Soil profile Site
Aria . St
Kasmia . St
El Jair
Aqaba
0 10 20 30 40 50 60 70
Kilometers
SYRIA
IRAQ
JORDAN
SAUDI ARBIA

FIGURE (2)

Mean MONTHLY TEMPERATURE and precipitation and (Humidity for 10 years)

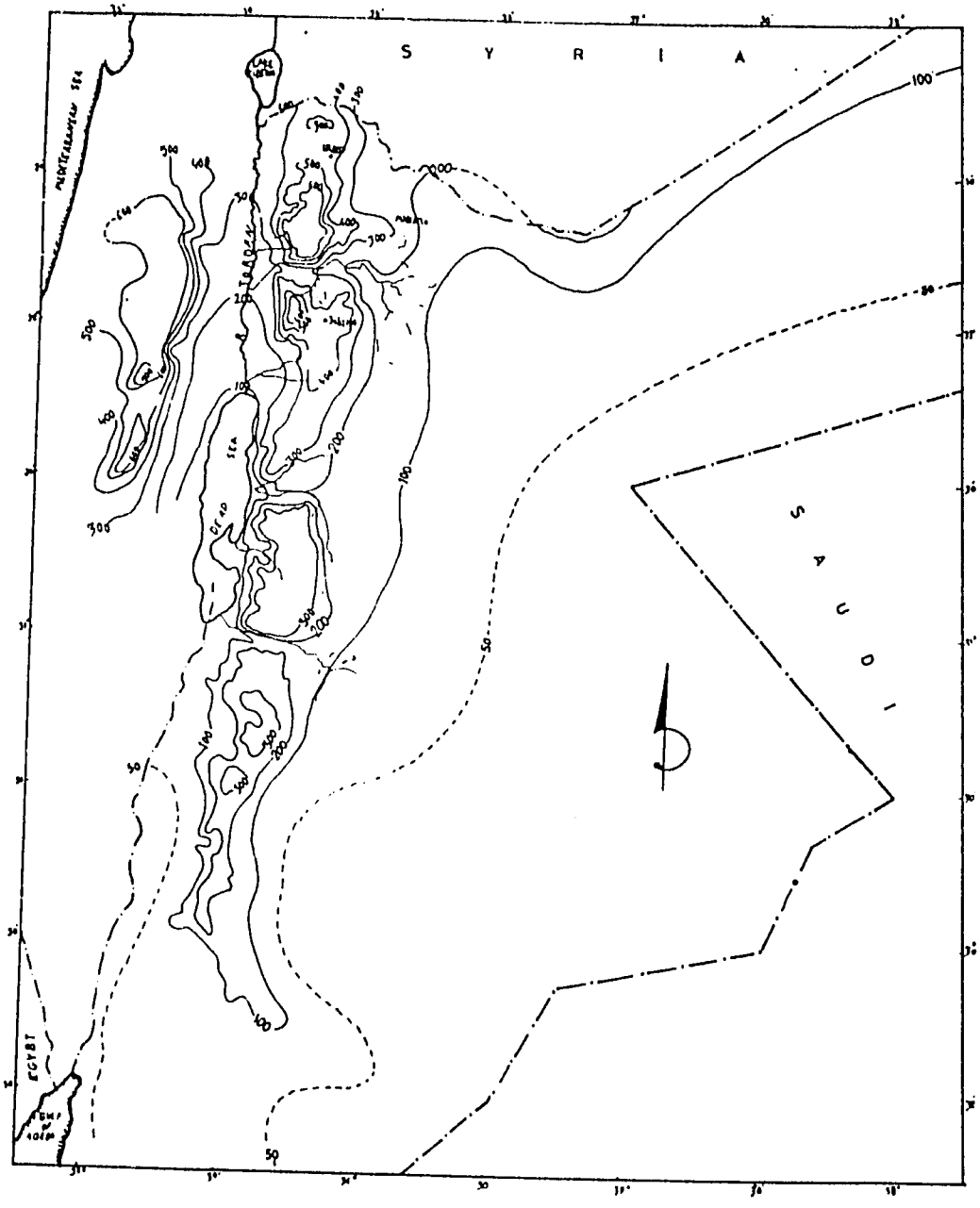
Item	Jan.	Feb.	Mar	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.	Mean annual
TEMPERATURE(c^o)	8.9	9.9	12.3	16.2	20.0	22.1	25.1	25.7	23.6	20.3	15.7	10.7	17.7
Precipitation in mm.	108.4	81.9	81.6	28.3	6.5	-	-	-	5.0	11.3	42.2	87.6	452.8
Average Relative humidity%	72	69	66	57	49	50	55	59	58	54	60	68	60

(Fig 3)



PRECIPITATION (mm.)

(FIG 4)



Geology And Geomorphology :

" Since Pre-cambrian times the granitic shield of East Jordan remianed a land surface surrounded by seas which received the erosion products from the land" (Quennel, 1959) .

Epirogenic movements during middle Cambrian, Triassic , Jurrassic and Cretaceous to the Oligocene resulted in marine transgression and regression, as a result , different strata were deposited . Rifting, northward movement tilting to the east and eruption of the basaltic mountains of the jebel Druse in the lower Miocene and Pleistocene resulted in the building of the present landscape shown in fig.(5) .

During these successive processes the regenerated drainage like Zerka river, Yarmouk, Mujib, etc. cut back further to the east revealing older rocks and eroding the product and depositing it in the Jordan rift valley floor. In addition to these main lithological groupings other units from Pleistocene to recent times are found. They include an association of limestone , marls and sediments of alluvial/ colluvial origin .

Population :

The total population of East Jordan is estimated at 2,323,000 (statistical year book, 1981), and the natural growth rate is about 3.8% per year.The population is concentrated as mentioned before in the 300 mm zone which is considered to be the most productive zone in Jordan after Jordan valley. The main towns located in this zone expanded rapidly. See the following table.

Amman, the capital, has increased in areas from 550 ha in 1956 to 1800 ha in 1981 . If the population in the main towns continue to increase at a rate of 3.8% , in 1990, 1,592,160 inhabitants will be living in these towns. This will result in further urban occupation of 91.70 ha. from the agriculture land, located in a zone of more than 300 mm rainfall.

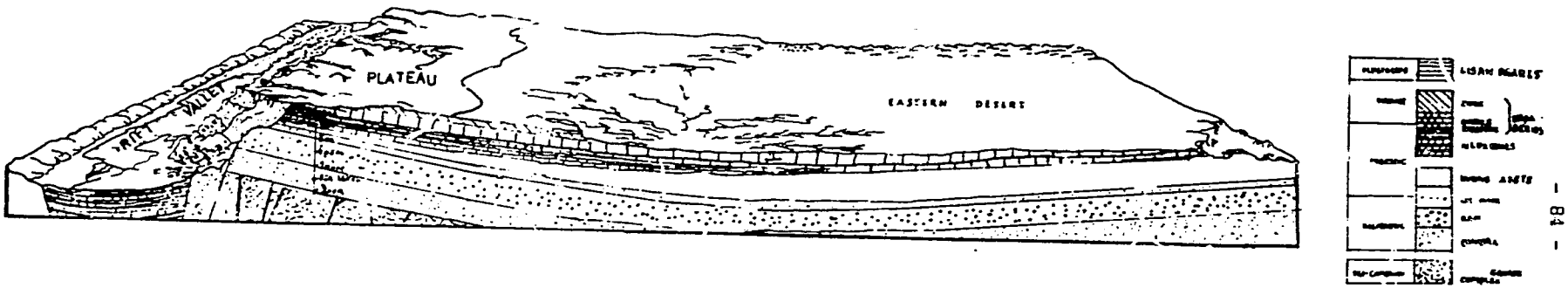


FIGURE (5)

SOURCE
RANGE CLASSIFICATION SURVEY, JORDAN, 1956

TOWNSHIP	AREA in ha.	RAINFALL ZONE MM	POPULATION
Greater Amman	18,000	300 - 500	889,875
Irbid	2,048	300 - 500	113,048
Salt	0,635	500	33,037
Madaba	0,543	300 - 500	28,236
Rathma	5,210	200 - 300	27,130
Sweileh	4,614	300 - 500	23,996
	31,550		1,115,322

SUMMARY :

Jordan has an area of 9.3 million ha. of which only about 0.75 million ha.(8.6%) receives an average of more than 200 mm of annual rainfall, whereas regions which have an average rainfall of more than 350 mm are only about 0.23 million ha. i.e. 2.5% of the total area. Moreover, this sector includes steep sloped, rugged territories , shrubby areas and urban zones. As such, Jordan with 2.3 million inhabitants concentrated in the last zone is regarded as an overpopulated country as far as its cultivated land is concerned. Due to irregularity and scarsity of rainfall, the total area cultivated varies from year to year, but it does not exceed 400.000 ha. The average area cropped in 1974-1978 amounted to about 219.000 ha. while in 1982 it was about 245.000 ha. The irrigated area is about 31.000 ha. (13%) of the total cultivated area, about 18.000 ha. 58% of the irrigated area is in Jordan Valley.

The area under the various land categories are shown in the table below Fig (6) :

Type of Land	Area in ha.	%
Cultivated land	245,000	2.6
Forest	40,000	0.4
Afforested area	47,000	0.5
Urban areas	30,000	0.3
Range & Barren land	8,950,000	96.2
T O T A L	9,302,000	100

Based on the 1982 agriculture census, the field crops occupied 85% of the cultivated area, vegetables 13% and tree crops 1[illegible] , see fig(7) .

Wheat accounts for 58% of the area cultivated by cereals, barley 28% and lentils 6% . Out of the 31,000ha of irrigated land , 67% is accounted for by vegetables, 20% by tree crops and cereals 1[illegible], fig (6) .

Landuse History in Jordan :

Jordan's agriculture has a long history and farming goes back to 200 B.C. or even before as shown by discoveries at Petra and other various old

settlements. Grain grinding mill stones and olive, vine shallow cicterus mills are distributed around various places such as Um-Quies, Salt, Ajlun in the north up to Karak, Showbak in the south .

Among the crops cultivated during the ancient times were cereals , olive, figs and vines.

Irrigation in the primitive form is believing to have started as early as Roman period or even before. It started in areas adjacent to springs and rivers. It was observed that the yields of irrigated crops was much more than those in growing without irrigation and usually were secured against the drought which very often occurred in Jordan. Besides the springs and rivers which were the original sources of irrigation water, shallow reservoirs (cisterns) were constructed or even dug in the hard rock for storing water collected from rainfall .

Traces of ancient irrigation systems, probably of Roman origin, are visible at Ma'an , Wadi Uweina Udruh and indicate the importance of finding storing and transporting water, both for domestic and irrigation purposes .

According to history, Jordan had a good vegetation cover allowing the production of wood for domestic needs and grazing a large number of animals. Due to the interference of man by cutting and burning the area of the natural vegetation it has decreased significantly .

Among the crops which were extensively grown during ancient times and which still occupy a considerable proportion of the land cultivated at present were cereals, vines and olives.

Landuse and crop pattern changes have taken place in most areas in Jordan due to economic reasons, the finding of new sources of irrigation water, insect damage, diseases, etc.... .

In the past five decades, Jordan experienced the greatest period of landuse changes. In the 1930's the great majority of the Jordanian people were depending on rainfed agriculture and animal husbandry to gain their living . Wheat production and orchard cultivation can be considered as the

backbone of the agricultural sector in the thirties .

Although using simple implements only, farmers produced a surplus amount of wheat and grapes that was exported to Palestine. Wheat export was in the range of 50.000 tons per year. These achievements could only be reached by appropriate landuse and implementation of traditional soil-moisture conservation techniques.

Farmers, using animal traction, ploughed along the contour-lines in order to avoid soil-erosion and surface run-off . Steeper lands were brought under fruit trees after being levelled to terraces. In orchards farmers used to plough twice : First, before the onset of the rains to allow for maximum infiltration of precipitation. Secondly, in spring to eradicate weeds. Without having gained knowledge on the principles of capilarity , farmers destroyed the capillary system of the soil by this second ploughing and decreased evaporation accordingly .

The general farming system was that of a two years rotation with winter cereals in the first and legume crops or fallow in the second year.

In the 1940's, Jordan faced the problem of population displacement and increasing migration. Thus, the country's agriculture resources became inadequate to meet the requirements of the population .

To overcome this problem, vegetables were introduced as summer crop. Furthermore, production could be improved by using new techniques like transplanting seedlings from nurseries to the field .

However, the increased income from summer vegetables and tobacco reduced the areas under wheat considerably and a decreased production of this important staple-crop is concerning the Government until now.

In the fifties, mechnization was introduced, resulting in ploughing up and down the slope instead of along the contour. This practice caused soil erosion and exposed the soil to dryness. Vast areas, previously fertile, were converted into badlands.

Despite the campaigns of the Ministry of Agriculture, farmers still practice this wrong method of ploughing .Coincidently, a widespread attack of phylloxera wiped out almost all of the vineyards in the mountaineous regions. The former orchards were mainly brought under winter cereals. By doing so, the carefully developed terraces were destroyed and mechanical ploughing further accelerated the problem of soil erosion.

In the sixties, and under the pressing need for food production the government concentrated on the development of irrigated agriculture in the Jordan Valley and in areas with groundwater being available .

Research work in the sixties concentrated on drought resistant cereal and tree crop varieties. Moreover, a programme to encourage soil conservation has been initiated .

After the occupation of the West Bank , Jordan again faced the challange of famine. More than 500.000 peaople came to the East Bank .

People cultivate marginal areas with rainfall below 200 mm per year. Besides, a further increase in soil erosion, ploughing eradicated the cover of annual and perennial (especially) grasses, resulting in a rapid decrease of the carrying capacity of the range-land. However, an increase in population required increased meat production. Under these conditions, overgrazing together with frequent drought, gradually damaged the range lands. Because of the lessening production of rangelands, farmers increasingly ploughed deeper products of steap lands within the rangeland to establish wild barley for grazing.

Redevelopment of the natural vegetation is becoming a target of national importance if Jordan does not want to lose its rangelands by desertification .

The seventies brought a major change in the employment patterns of the country . Occupation in other sectors than rainfed agriculture became more profitable and many rural people moved to the towns . In terms of area, Amman has expanded a hundredfold since 1945 - mainly at the expense of fertile land.

Land fragmentation to uneconomical small units is another problem. To counteract this situation , agriculture cooperatives for rainfed areas have been establishment.

Present Landuse .

Rainfed Agriculture :

Rainfed agriculture plays an important role as the main sources of basic food products, such as wheat, lentils and animal products. This is due to the fact that water resources in Jordan are poor. Groundwater is limited and the total quantity of annual rainfall is estimated at 6 million cubic meter. The major crops cultivated in this zone are as follows:

1) Cereals :

Over 85% of the rainfed area in Jordan is under cereals and legumes during the growing season from November to June. The growth and yield solely depend on the rainfall occurring during this period. Irrigated cereals are limited to Jordan Valley and Qa-Disi .

A breakdown of the various types of cereals and legumes is shown below :

C R O P	AREA In Ha.
Cereals	101,964
wheat	486,629
barley	15,600
maize	2,332
legumes	10,790
lentils	3,390
vetch	2,020
chick-peas	

2) Tree Crops :

Olive and vines are dominant in orchards. They are found all over Jordan up to elevation of (1000 m) or more. They are cultivated alone or are intercropped with other crops, such as cereals or summer vegetables.

The total area cultivated with olives is estimated to be 30211,6 ha. whereas the area under grapes is approximately 2788.7 ha.

3) Almonds and others :

These crops are usually intercropped with cereals and are grown in both plain and hilly areas such as Ajlun and Shubak . The recent is to establish plantations in monocultivation .

The following table gives the area of almonds and other tree crops:

C R O P	Area in ha.
Almonds	101,6
Apple	119,3
Apricot	20,3
Peachs	58,7

4) Vegetables :

Summer vegetables are grown especially in years of higher rainfall. Tomatos and watermelon are the main crops. The area under summer vegetables is subjected to great annual changes, so, it is difficult to give exact figures.

5) Tobacco :

Tobacco is cultivated in the highland areas around Irbid, Salt and Madaba . The total area cultivated in a normal year is about 7640 ha. Out of which 10 ha. are under Tombac, and 430 ha. under local tobacco .

Jordan Valley :

Irrigated Agriculture :

The total irrigated area in Jordan is estimated to be around 40.000-50.000 ha. About 31.000 are currently under irrigation, the expansion of irrigation is restricted by the availability of water resources and in Jordan these are quite poor.

Groundwater and rivers are more or less sufficient to irrigate, the present 30.000 ha. in addition to drinking water supply. The total quantity of annual rainfall is estimated to be in the range of 6 million cubic meters.

1) Tree Crops :

The total area is about 11,000 ha. in extend. Citrus orchards constitute 90% of the total irrigated area by tree crops,bananas by 9% and plam trees by 1% .

The main citrus varieties grown are lemon, oranges , clementina, mandarin rin and grapefruit .

The overall proportion of these varieties is as follows :

Lemon	28%
Ornage	27%
Clementine	21%
Mandarin	18%
Others	6%

Minor plantation can be found in some places such as Wadi Jarash, Arab, Wahala, Ibn-Hammd and Karak .

2) Vegetables :

The area planted with various types of vegetables is given below. Most of these vegetables are grown in both Jordan Valley as well as Wadi Dleil. All types of vegetables could be grown in Jordan . However, where

and how many vegetables will be planted depends upon many factors such as soil, climate, land fragmentation, availability of water and marketing conditions. Tomatoes are the most important vegetable (18% of the area) followed by eggplant (8%), squash and beans (16%) .

CROP	Area/ha	%
Tomato	3738	18
Eggplant	1661	8
Squash	3322	16
Cucumber,Pepper	1869	9

The cultivation of out of season vegetables under plastic tunnels amounted to about 900 ha. and about 150 ha. were grown under greenhouses. The kind of crops grown are mainly cucumbers and tomatoes and of a lesser extent melon, peppers, beans and squash .

Livestock :

The following table shows the national livestock resource in 1981 :

Livestock	Heads
Sheep	1,073,100
Goat	0,529,700
Cattle	0,036,300
Camels	0,015,800

Sheep and goat flocks from the pastoral zone produce 80% of the total red meat in Jordan and the rest is produced in equal amount by the cattle and camel herds. Overgrazing and the encroacnment of cereals on lands which are more suited for grazing severly reduce the productivity of the range land which provides 70% of the fodder required by the livestock.

Poultry industry has rapidly developed due to high investments of the private sector. In general and according to 1979 census, the country reached self sufficiency in egg production.

Source : Ministry of Finance/Custom
Agri-cencus 1982

Landuse Planning :

From the foregoing sections, it could be concluded that the present landuse in Jordan is unbalanced and suffering from conflicting interaction between the various major landuse For example, the urbanised areas are gradually increasing at the expense of the potential agricultural land, thus, reducing the production areas of basic food such as wheat . The currently marginal land (200 m isohyt) is brought under cultivation at the expense of range land increasing erosion and desertification . Moreover, the demand for recreational facilities is growing fast as a sequence of the changing life style in Jordan. Therefore, the landuse planning in its wide concept is becoming an important factor in achieving a balanced exploitation of the natural resources.

The main objectives for any landuse planning in Jordan can thus be summarized as follows :

1) The use of any potential agricultural land for increased production of basic food crops according to land capability .

2) Promotion of afforestation , especially around dam sites in order to reduce soil erosion and to create recreational facilities .

3) Compact development of urban centers and industries .

In order to attain these objectives definite principles and methodology should be strictly followed both on large scale (national) and small scale (farmers) . The following section gives some details concerning landuse planning on farmers level.

Landuse principles and Methodology :

The purpose of landuse planning is to achieve a balanced exploitation of natural resources, ensuring optimal and continuous productivity .

Landuse planning encompasses any human activity which influences

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Source : Dep. of Vete Services 1982

natural vegetation and original land form .

Because of the broad field, landuse planning serves to avoid concentration on one aspect such as forestry or agronomy, but covers all aspects of resources development .

Landuse planning takes all these aspects into consideration and their consequences . In this way a balanced development can be achieved , taking into account :

Climate
Soils/land capability
Social and socio-economic aspects
National/regional development goals
Present landuse/infrastructure/farming system
Present levels of farm management

Depending on the land and the people utilizing it, various methods of landuse planning have to be adopted to conform with present stages of development , future goals and specific problems of area, which may be climatic, physiographic or socio-economic .

For the ZRBP as a pilot programme for sound highland development a specific "Safe Landuse Framework" was developed .

Due to the great variety in physiography, soils and climatic conditions in the highlands it is impossible to limit landuse planning to a simplified form. Sizes of holdings vary greatly and farmers are of an individualistic frame of mind. Socio-economic aspects vary greatly.

Using administrative or catchment boundaries in this case as a basis for landuse planning and development would lead to great resentment on the farmers side and inevitable failure of any form of sustained landuse.

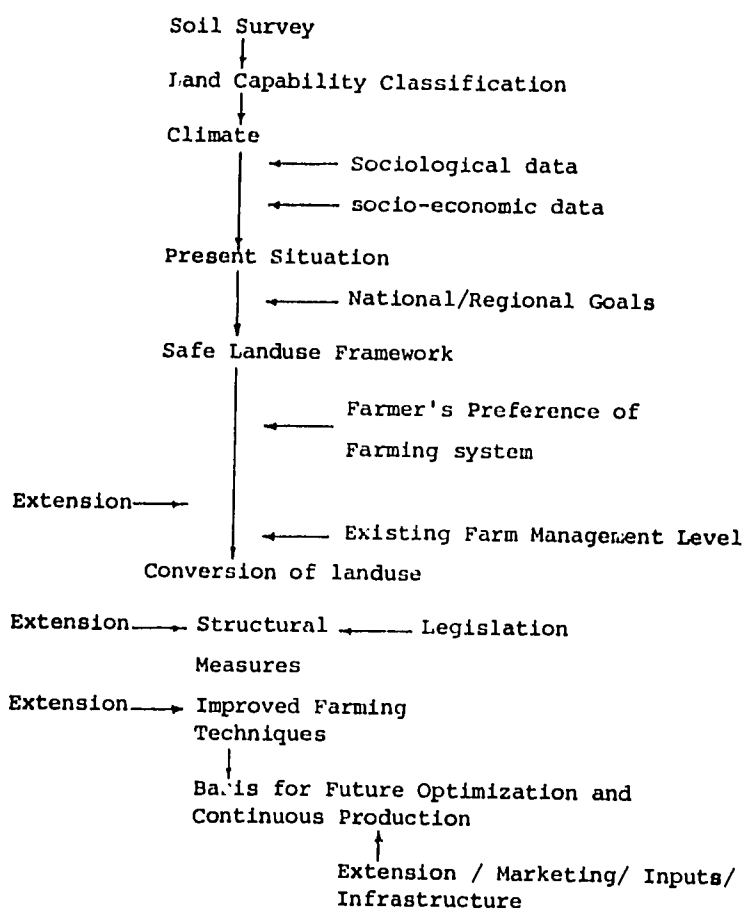
As various farming systems can be adopted by farmers under the same ecological conditions, individual farm planning has to be adopted. The " Safe Landuse Framework" provides a series of landuse alternatives per land

class according to specific climatic conditions.

The individual farmplanning not necessarily takes more time and effort once a sound system has been developed . Through extension sufficient interested parties are created to allow farm level planning to continue from holding at virtually the same pace as catchment planning would take.

In its implementation landuse forms the basic key not only to agric. development but also to soil conservation. Structural measures are a support to prevent erosion where really required . But when proper landuse has been adopted these measures can be brought back to the absolute minimum.

As a basic for agriculture development :



Extension forms the basis for all development while legislation should back up the system to avoid a minority to block development. However, through legislation alone development can never be achieved.

The landuse plan forms a coordination basis for implementation. Also during implementation it is the task of any landuse planner (or unit) to co-ordinate and oversee the development of timeliness and sequence .

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SOIL CONSERVATION AND EROSION IN JORDAN

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Introduction :

Man's struggle with soil erosion is as old as agriculture itself. It started when the earliest nomadic tribes first upset Nature's delicate balance between plant cover and the erosive forces of wind and water. As man becomes civilized his demands upon land for additional food and clothing grew. This change from nomadic herding to fixed mode of agriculture led to the destruction of plant cover and exposed more of the soil to the erosive forces. So, his efforts (Man) were mainly attempts to prevent the scouring effects of surface runoff without knowing the exact nature of the forces. In some cases, he was aware of the fact that erosion does'nt exist when the land surface is protected by plant cover. The protective influence of plant cover was thought to be that it retarted the flow of surface runoff and kept it spread uniformly over the surface as it moved downhill. Some attribute this protective effect for plant roots binding the soil and stabilizing it against the erosive action of water and wind. It is just in the beginningof 1950's when scientists discovered that the "IMPACT" of raindrops on bare soils and the resulting "SPLASH" was the major cause of soil erosion by water .

In this country the soil conservation activity started in the late 50's, when the American aid began their activities by constructing soil dams and earth banks to preserve water for the nomadic bedwins for drinking purposes and to conserve water in soils. These effects were

restricted in eastern part of Jordan. The efforts undertaken by the American aid were accompanied by individual initiatives which were encouraged by the Ministry of Agriculture due to the following reasons:

1. The farmer's change from horiculture to cereal croping.
2. The use of unsuitable ploughing methods together with the device
3. Investing the marginal land in different agricultural practices due to the increase in population .

In the early 1960's , the Ministry of Agriculture realized the importance of this problem and started establishing several projects with the cooperation of FAO to improve the agricultural situation by following modern techniques and systems . These new systems were reflected on the farmers by : -

1. Supporting financial expenses to the farmers to improve their rainfed regions (250 cm) .
2. Based on (1), the farmers were able to take share in conserving soil and in the improvement of their land.

After this period, the Ministry started planned projects in the middle (Baga area) and in the southern part (in Karak district) . This period was noted for its applied research and through practical demonstration on the farmer's fields considering the : ploughing and planting on contours, ploughing against slopes, and constructing stone terraces to slow down the movement of water and restore it in soil.

PART 1 :

Wind and water are the active forces of erosion inspite of the way they act and in the result they leave behind. But or still they are similar in the sense that both remove and transport surface soil. Soil erosion is as old as soil formation, are constant processes under

virgin soils and growing cultivated crops accelerate erosion. It is this accelerated erosion that causes the destruction of natural soils and greatly reduces soil productivity .

Many areas of highly productive land in this country are being permanently lost to crop production by the urban sprawl of cities, the establishment of roads and highways and the development of airports and industrial areas .

Soil erosion, however, is the main force acting to deplete the productive capacity of our soils today. In the more humid regions, erosion is largely effected by water while in the semi-arid and arid regions the wind is the principal culprit (or factor) .

A- Wind Erosion :

Wherever the soil is bare, the surface loose and dry, and the wind strong, erosions may be expected unless control measures are being practiced . The main cause of wind erosion is high velocity wind and a lack of vegetation on the land.

The wind erosion process goes through several major phases, as follows : start of the movement of soil, its transportation, sorting abrasion and deposition.

The direct force of the wind against soil particles dislodges them from their position on the surface . They move a short distance and then suddenly shoot upward in a jumping movement and this process is known as " saltation " . Some of the particles jump a short distance, other jump a foot or several feet, depending on the velocity of the wind. As the particles rise and fall through the air, they gain considerable momentum and continue to increase in velocity until they again strike the ground. As their speed increases, they hit other particles on the ground , causing these to creep forward. This is known as surface creep.

The erosive wind is extremely turbulant; the degree of turbulance at the land surface varies directly with the roughness of the ground. This turbulance is what makes the soil erode.

In brie rough ground surface is more resistant to wind erosion than a smooth one. It slows down the wind velocity and tends to trap whatever particles are moving along the surface. Growing vegetation and crop residues act as a protective cover, they do have a greatest capacity to trap the moving soil and even to prevent it when the cover is dense. Beside these practices, addition of organic matter, interplanting , use of stubble mulch, and the shelter belt, are means to trap the drifting soil and to control wind erosion .

B - Water Erosion :

Water erosion takes place whenever rainfall exceeds the surface storage capacity and infiltration rate. Water causes erosion by detaching soil particles from the surface soil mass and transporting them, usually downhill. It may do this on any area where there is a natural precipitation or where water is applied artificially to land surface. The erosive action of water is greatest and most destructive where the vegetation (plant cover) has been removed, exposing bare surface to direct action of rainstorm.

The movement of soil by water is a complex process. It is influenced by the amount, intensity, and duration of rainfall, amount and velocity of surface flow, nature of soil, ground cover, slope. Soil material must first be dislodged, splashed, rolled, carried in suspension along the surface ; these processes are the result of raindrop splash, and the turbulance that was caused by the splash and the flowing water. So the two principal erossive agents that become active on land during rain storms are falling raindrops and flowing water.

Thus, the destructive action of soil erosion - soil deterioration is of considerable local importance in many forest and range areas and especially on land used for cultivated crop production . Its importance comes from its relation and effect on : -

- Grasing and forest land
- Drainage and irrigation canals
- Fisheries
- Public health
- Silting of reservoirs

PART 2 :

As there are no available data on soil loss and related problems, and due to the importance of this subject, I started tuckling this matter by selecting three different climatic sites of which I was fortunate to start one experiment in the northern part of the country in 1981 - 1982.

The aim of this experiment was to study the effect of some agricultural practices on soil loss and moisture retention.

The experiment was conducted by Dr. Tamimi and myself in 1981 - 1982 in Mar'o station . The field has a 2-4 % slope with a texture of clay to clay loam. For this purpose, twelve plots each 22.13 m long and 6.66m wide were used. Four treatments with three replicates were set in a Randomized complete Block Design; the treatments are :-

1. Ploughing pro slope (control)
2. Ploughing against slope
3. Without ploughing
4. Mulching without ploughing

In the termination of the experiment eroded material was collected and weighed . Soil samples were taken to a depth of 30 cm for moisture determination .

The results of this experiment (table below) showed that there was a highly significant differences between treatments

Treatment	% moisture 30cm depth	eroded soil Kg/ha
1. Plougning pro slope	11.7	538
2. Ploughing against slope	12.8	460
3. without ploughing	10.2	546
4. Without ploughing + mulch	12.0	372

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A SYNOPSIS OF THE BENCHMARK SOILS PROJECT

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INTRODUCTION :

The Benchmark Soils Project was established in 1974 to test the viability of an analogue approach to the transfer of agrotechnology in the tropics that is based on soil classification. The project comprises two companion research contracts awarded to the Universities of Hawaii and Peurto Rico in 1974 and 1975, respectively, by the United States Agency for International Development . While the smaller project of the University of peurto Rico terminated in 1981, the project of the University of Hawaii will conclude its work in 1983 .

At the first comprehensive study of its kind , the Benchmark Soils Project ventures to scientifically scrutinize the transferability of agroproduction technology, particularly soil and crop management practices. Central to this effort is the benchmark soils concept and the soil family as defined in U.S. system of soil classification, Soil Taxonomy (Soil Survey Staff, 1975) The intent of the soil family is to group together soils that are relatively homogeneous in properties important to plant growth. Consequently, comparable phases of all soils of a family should have a common and predictable responce to management, correlative input-output characteristics , and similar crop production potential. The hypothesis of transfer by analogy which underlies the project is derived from these principles and is that empirical agroproduction experience gained with a soil of particular family can be transferred and extrapolated to all comparable members of that family, irrespective of their geographic occurrence .

PROJECT OBJECTIVES

The general aim of the Benchmark Soil Project is to experimentally and statistically evaluate the above hypothesis. The primary research objectives are :

1. To demonstrate that soil management and crop production knowledge can be transferred among tropical countries on the basis of soil families as defined in Soil Taxonomy.

2. To establish that the behaviour of tropical soils and their potential for food production under various levels of management inputs can be predicted from soil taxonomic units.

A secondary objective is to expand the knowledge base for the management of tropical soils in particular consideration of the economic decision environment of the resource-poor farmers in the less developed countries.

RESEARCH ACTIVITIES :

In the context of the project agrotechnology transfer is defined as the extrapolation of a response-input relationship, estimated from a known experimental situation, to other similar agroenvironments. For the scientific and quantitative assessment of the transferhypothesis, the project chose to study how a test crop would respond to a technology in a number of widely seperated locatoins.

The basic research strategy of the Benchmark Soils Project is to conduct a series of identical experiments in networks of soils belonging to the same families, monitor crop performanceand weather and soil conditions, and statistically compare responseto management in the form of yields.

In concurrence with the recommendations of a workshop on Experimental Design for Predicting Crop Productivity with Environmental and Economic Inputs held in Honolulu, Hawaii, in 1974, the design used in the so-called transfer experiments is a randomized complete block with 16 treatments, replicated three times. The first 13 treatments are according to Escobar's modified 5^2

partial factorial describedby Laird and Turrent (1981). This design has 13 of the 25 possible combinations of the five levels of each of the two factors. It covers the design space well, thus allowing the fitting of second order responsesurface from a limited number of treatments. Variables in the transfer experiments are levels of phosphorus and nitrogen, with maize as the indicator crop. All transfer experiments are drip-irrigated and standarized throughout the network. (For details and field procedures, see Benchmark Soils Project Staff (1982)) .

The transfer experiments are complemented by pragmatic soil and crop management experiments designed in collaboration with host country institutions to provide information on economic and efficient agronomic practices. Variety trials were conducted in the early stages of the project to identify cultivars that are well adapted to the various agroenvironments and responsive to the fertility variables used in the transfer experiments.

Three contrastingly different soil families representing three distinct agroclimatic zones of the tropics were selected for experimentation : the thixotropic isothermic Hydric Dystrandepts ; the clayey, kaolinitic, isohypethermic Tropeptic Eutrustox; and the clayey, kaolinitic, isohyperthermic Typic Paleudults.

The project has established a research network that comprises 23 experiment sites in Brazil , Cameroon, Hawaii, Indonesia, the Philippines, and Puerto Rico. Collaborating with the project are the Empresa de Pesquisa Agropecuaria de Minas Gerais in Brazil, the General Delegation for Scientific and Technical Research in Cameroon, the Philippine Council for Agriculture and Resources Research in the Philippines , and the Center for Soil Research in Indonesia.

To date the project has completed the following experiments at the various locations :

K sites. This specific criterion is called the prediction or transfer statistic (p) .

PRELIMINARY RESULTS :

Applying the P-statistic to the yield data gathered from the three soil familiies, the following results were obtained (Benchmark Soils Project, 1982 a and 1982 b) :

Dystrandepts	P = 1.06
Eutrustox	P = 1.50
Paleudults	P = 1.15

Since P-statistic values of 1.0 and slightly larger than 1.0 demonstrate predictability and transferability , the above values indicate that the response to applied phosphorous can be transferred among the sites of the same family , provided a measure of soil phosphorus is included in the transfer model. The relatively large P value for the Eutrustox reflects a moderate distortion of prediction but nontheless aupports the transfer hypothesis, although less conclusively .

In addition to the P-statistic, the confidence interval procedure and a graphical method were used for the Eutrustox yield data. These techniques also gave positive evidence for transferability (Benchmark Soils Project,1982a).

The management experiments conducted by the project dealt with cropping systems nitrogen-fixing fuelwood trees, phosphorus source and placement, plant pests, liming , mulching, plant population density, irrigation , and soil erosion. A description of these experiments and their results are summarized in two recent project reports (Benchmark Soils Project, 1982a and 1982b). These reports also contain other project accomplishments such as training activities symposia, worksnops and conferences; communication and dissemination; and publications.

SOIL	EXPERIMENTS		
	Transfer	Variety	Management
Dystrandepts	57	3	22
Eutrustox	51	4	13
Paleudults	49	5	13
Subtotal	157	12	48
T O T A L		217	

The yield data from the transfer experiments were analysed with a state-of-the-art methodology for quantitative evaluation of transfer developed by the project (Cady et al. ,1982) . General aspects of formulating the transfer model have been given by Beinroth et al. (1980) . An outline of the procedure is as follows (Benchmark Soils Project, 1982) :

1. Calculation of a site-specific prediction equation for each of the K sites based only on yield data for that site. The differences between the site-specific predicted yields and the observed yields are called site-specific residuals .

2. Identification of the general nature of the transfer model. The simplest model would include the same components as the site-specific prediction equation of the first step. More complex transfer models incorporate uncontrolled site variables .

3. Estimation of the selected transfer model for each set of (k-1)sites.

4. Predictions of yield for each plot at one site using the transfer model estimated in step 3 from the data of the other (k-1) sites. The differences between the transfer predicted yields and the observed yields are called transfer residuals and are calculated for each site.

5. Calculation of the ratio of the transfer residual sum od squares to the site specific residual sum of squares where both sums are added over

CONCLUSION :

The preliminary results of the Benchmark Soils Project show that transfer of soil managment practices can be successfuly achieved and yields can be predicted with considerable accuracy on the basis of Soil Taxonomy families, if additional site factors are taken into account. By implication, this validates the concept of the soil family as postulated in Soil Taxonomy and the principle of Benchmark soils. A comparison of the results obtained in soil fertility and management experiments at the various sites of the project netwrok also shows that Soil Taxonomy stratifies the agroenvironment into distinct niches of agroproduction and allows qualitative predictions of soil potential and management requirments. In conjunction with soil survey, Soil Taxonomy thus defines the geographic and pedologic applicability of agronomic experience.

At the same time, the project results allude to the limitations of analogue transfer for agrotechnology based only on Soil Taxonomy taxa. Soil Taxonomy constitutes an effective vehicle for agrotechnology transfer in cases where a high degree of specificity is not needed, such as in large-scale land use planning . Transfer of agrotechnology to specific farm situations, however, requir a more holistic approach that should be based on systems analysis and employ a computer simulation techniques to model that soil-weather-crop-management continum

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IBSNAT -- An International Program of Agrotechnology Transfer

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ABSTRACT. IBSNAT, the International Benchmark Sites Network for Agrotechnology Transfer, is a collaborative endeavor that consolidates a group of national, regional and international agricultural research centers into a prototype network for the purpose of developing, validating and utilizing a scientific methodology for the effective transfer of agrotechnology in the lower latitudes which is based on a systems approach and simulation techniques. Realizing that in successful transfers the characteristics and requirements of cultivars must be compatible with the environmental conditions at the transfer site, quantitative knowledge of the genotype-environment-management interactions must be generated and incorporated into crop performance simulation models. Field experimentation is thus focused on collecting balanced sets of a minimum of soil-crop-weather-management data that monitor the whole crop system. The crops studied include four cereals (maize, rice, sorghum, wheat), three grain legumes (beans, groundnuts, soybeans) and three root crops (aroids, cassava, potatoe). Guidelines for the experiment designs and detailed procedures for data collection have recently been completed and circulated to IBSNAT collaborators.

INTRODUCTION

In the next 20 years the world will have to feed two billion more people. Ironically, food shortages of major proportions are expected to arise among the agrarian countries of the tropics and subtropics where the major part of the as yet unexploited or underutilized resources of arable land of the world are located. Advantageously, the knowledge about the management of these resources for the production of food and fiber has dramatically increased in recent decades through the work of the national and international agricultural research centers. But the work of these institutions becomes meaningful only when the results can be effectively conveyed to the ultimate user--the farmer--in all areas where they are environmentally and sociologically applicable. It is distressing, therefore, that the development of operational methodologies for the efficient diffusion of agroproduction technology has lagged behind the knowledge generation process. Research and development efforts relative to the transfer of agrotechnology must consequently be augmented so that the existing and rapidly growing knowledge base can be

shared by many users in the countries of the Third World. This is particularly crucial for countries which lack the capital and human resources to set up national research programs or cannot delay their agricultural development until their own research has yielded implementable results.

In the context of this perspective, the International Benchmark Sites Network for Agrotechnology Transfer, IBSNAT, has been established to develop and test a methodology for integrating scientific and technological knowledge of agricultural production into systems that optimize resource management and facilitate the transfer of technology in the tropics and subtropics.

IBSNAT is an outgrowth of the Benchmark Soils Project of the Universities of Hawaii and Puerto Rico and has had a long gestation period. The idea of a network was first discussed at a workshop on "Operational Implications of Agrotechnology Transference Research" held at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in October 1978. Another milestone event in the project development was an international panel consultation on the "Strategy for Land Evaluation and Agrotechnology Transfer in the Tropics and Subtropics" which was instigated by the Benchmark Soils Project and hosted by FAO in Rome in March 1980. IBSNAT is funded, in part, by the United States Agency for International Development (AID) under a nine-year contract with the University of Hawaii which became effective in September 1982.

Although the University of Hawaii serves as the coordinating entity and as the project headquarters for IBSNAT, the success of the project will depend on the aggregate research output resulting from the concerted efforts by the various collaborators who in their entirety form IBSNAT. Through the aspired synergistic cooperation of institutions from many countries, IBSNAT holds the promise of emerging as a major scientific endeavor of a multidisciplinary nature and international scope of consequence to the agricultural development in the lower latitudes.

APPROACHES TO AGROTECHNOLOGY TRANSFER

Uehara (1981) defined agrotechnology transfer as the taking of an agricultural innovation from its site of origin to a new location where it is likely to succeed. How, then, are the innovations transferred from one location to another? Most commonly transfer of agrotechnology occurs through trial and error, but there also exist scientific methods. Swindale (1980, 1981), drawing in part on the work of Nix (1968,1980), has identified three different but not mutually exclusive approaches.

Transfer by Analogy

In this method soil and climate classifications are used to identify analogous areas. The assumptions are (i) that the form of the classifications stratify the environment with sufficient precision to allow successful transfers, and (ii) that all occurrences of a defined class have similar production potentials and responses to management. While general, multi-attribute schemes of agroclimatic classification are of limited value in the analogue transfer of technology (Burgos, 1968), soil classifications have been more successful. The U.S. system, Soil Taxonomy (Soil Survey Staff, 1975), is particularly suited for this purpose as it incorporates both soil and

and climate and thus stratifies the agroenvironment into distinct niches of agroproduction (Beinroth, 1984).

Transfer by analogy is also implied in the concept of benchmark soils advanced by C.E. Kellogg (1961). As currently defined, a benchmark soil is an important soil selected for intensive study and complete characterization because it occupies a key interpretative position in the classification and/or covers large areas (Miller and Nichols, 1980). A benchmark soil represents a referense site from which research results can be extrapolated to other areas with similar characteristics.

Soil scientists have long assumed that soil classification, in conjunction with soil surveys, provides an adequate basis for the transfer of pedologic knowledge and agronomic experience. Many authoritative statements can be found in the literature which allude to this conjecture. In the foreword to the FAO-Unesco Soil Map of the World (FAO, 1974), for example, it is stated that one of the objectives of the map is "to supply a scientific basis for the transfer of experience between areas with similar environments...(because)...with the tremendous amount of knowledge and experience gained in the management and development of different soils throughout the world, the hardship perpetuated in some areas by methods of trial and error is no longer justified." And G.D. Smith (1965) pointed out that "we make the basic assumption that experience with a particular kind of soil in one place can be applied to that particular kind of soil wherever it exists if consideration is taken of any climatic differences."

The stated assumptions and the transfer hypothesis implied therein were subjected to a thorough scientific test in the Benchmark Soils Project (BSP) of the Universities of Hawaii and Puerto Rico whose primary objective was to test the transferability of agroproduction technology on the basis of soil families as defined in Soil Taxonomy. The results of the BSP (Benchmark Soils Project, 1982a and 1982b) show that Soil Taxonomy taxa allow to predict crop production potential and management requirements in qualitative terms and that, logically, the specificity of predictions increases with decreasing categoric levels. The extensive experimental and statistical work conducted by the BSP also showed that fertilizer response and crop yields can be predicted with considerable accuracy at the family level if additional site factors are taken into consideration (Benchmark Soils Project, 1982a).

The importance of this proviso has also been emphasized by Smith (1981) who, in his last technical paper, wrote that "soil interpretation at any categoric level nearly always requires an additional step of reasoning which includes the relation between the potential use being considered and the soil properties. This requires knowledge of soil and non-soil factors that cannot be inferred from the classification."

Statistical Relationships

In this approach, correlations and multiple linear regressions are used to relate crop yields to input and resource variables. This site factor method is widely used, but works better with interpolations rather than extrapolations and thus appears to be of limited value for intercountry transfers (Swindale, 1980).

Simulation Models

These models employ systems analysis to reduce the complex system into a number of simpler components and to identify the linkages between them in an attempt to mimic the behavior of the complex system (Nix, 1980). Inherently such models should have the best potential for agrotechnology transfers, but the incompleteness of scientific knowledge, particularly relative to the cause and effect relations that control the genotype-environment-management interactions, and the complexity of the models themselves have been barriers to their use. The difficulty to achieve the multidisciplinary collaboration that is clearly required to develop the models may have been a further detriment (Swindale, 1980). Recent advances in the simulation of agricultural processes and the rapid development of computaional tools, however, now make it possible to synthesize large amounts of soil, climate, crop, and management data in new and useful ways. Also, as Nix (1980) has pointed out, the development of simulation models is essential to identify the "minimum data set" needed for the adequate interpretation and extrapolation of experiments results. This minimum data set consists of a cultivar-specific, balanced set of soil-crop-weather-management data and is, in turn, a key prerequisite for technology transfer via simulation models.

In the light of the preceding, it should be obvious that a quantitative model of agrotechnology transfer must necessarily be more complex than the somewhat simplistic approach of analogue transfer that was tested by the BSP. Since the intricacy of the transfer process clearly calls for a holistic approach, IBSNAT has opted to adopt a methodology that is based primarily on concepts of transfer by simulation.

Central to this approach is the realization that in successful transfers the characteristics and requirements of cultivars must be compatible with the environmental conditions at the receiving site. This implies the availability of (i) quantitative knowledge of the interactions of the soil, crop, weather, and management and (ii) quantitative knowledge of certain environmental characteristics of the recipient site.

Parenthetically, it may be noted that models are means and not ends that are developed for mainly three reasons (R. A. Nix, personal communication):

1. Understanding of processes or basic research;
2. Predictions or strategy decisions, and
3. Control of processes or tactical decisions.

Each of these kinds of models has different data requirements and characteristics. Models of the second and third kind are particularly relevant in the context of agrotechnology transfer.

IBSNAT's GOALS AND OBJECTIVES

The goal of IBSNAT is to increase the effectiveness of agricultural research in the tropics and subtropics by employing a methodology that will allow the rapid diffusion and sharing of the findings of this research and facilitate judicious land resources management. Key elements of this methodology are networking, and the modelling of agricultural processes and the genotype-soil-climate-management interactions.

The primary objective of IBSNAT, therefore, is to develop and validate performance prediction models for important crops of the tropics and subtropics that combine elements of transfer by analogy with systems analysis and computer simulation techniques and that will

- accelerate the flow of agrotechnology from its site of origin to new locations,
- increase the success rate of transfers of agricultural technology in the lower latitudes,
- assess the long-term effects of agricultural practices on the soil resource, and
- guide land use decisions.

MAJOR IBSNAT ACTIVITIES

Network Establishment

IBSNAT consolidates a group of collaborating agricultural research centers in a prototype network for the purpose of generating the data base for the development of crop performance prediction models and testing their validity. This worldwide cluster comprises National and International Agricultural Research Centers and Regional Research Organizations that are willing to finacially and technically support the research effort and whose stations represent the dominant agroecological zones and the major kind of soils of the tropics and subtropics.

Currently, 16 national, three regional and three international agricultural research centers in Central and South America, Africa, the Middle East, the Caribbean, the Indian Subcontinent, Southeast Asia, and Oceania participate in IBSNAT. Examples of national, regional and international collaborators are the Centro Nacional de Investigaciónes Agropecuárias (CENIAP) of Venezuela, the Arab Center for the Studies of Arid Zones and Dry Land (ACSAD) in Syria, and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, respectively.

Data Generation

Site characterization. In collaboration with the AID-sponsored Soil Management Support Services of the USDA Soil Conservation Service, the soils of all IBSNAT sites are described, analyzed and classified according to the standards of the Soil Conservation Service. Characterization analyses are performed at the National Soil Survey Laboratory of the Soil Conservation Service at Lincoln, Nebraska; classification is to the family level of Soil Taxonomy. Each IBSNAT site further requires a weather station capable of recording, as a minimum, precipitation, temperature and solar radiation on a daily basis.

Agronomic experiments. At a symposium on "Minimum Data Sets for Agrotechnology Transfer" held at ICRISAT in Hyderabad, India, in March 1983, IBSNAT collaborators selected ten crops and agreed to conduct standardized experiments conducive to expanding the knowledge base required for modelling the soil-crop-climate continuum for agrotechnology transfer. The crops in-

clude four cereals (maize, sorghum, rice, wheat), three grain legumes (beans, groundnuts, soybeans) and three root crops (aroids, cassava, potatoes). To ensure that all collaborators follow common experimental procedures and collect compatible minimum data sets from the field trials, IBSNAT has recently prepared and distributed detailed guidelines on "Experimental Design and Data Collection." The procedures call for the collection of cultivar-specific minimum data sets that include the following:

(1) general information,
(2) soil characterization and classification,
(3) daily weather,
(4) preplant soil nutrient analysis,
(5) plot management information,
(6) phenological observations,
(7) dry matter production,
(8) final yield and yield components, and
(9) post harvest soil nutrient analysis.

The first IBSNAT experiment with maize and cassava was installed by scientists of the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Turrialba, Costa Rica, In June 1983. Most collaborators, however, are currently in the process of selecting and characterizing their sites. To date, some 30 research sites have been identified by IBSNAT collaborators in 15 countries.

Data Base Management

The minimum data sets from IBSNAT experiments are designed to be used with a single data management system that will permit researchers to record, store, retrieve, and analyze experimental data with either standard statistical techniques or a number of simulation models available to IBSNAT collaborators. The IBSNAT data base management system, developed mainly at the Institut National de la Recherche Agronomique (INRA) in Toulouse, France, is located at the project headquarters at the University of Hawaii.

Model Development and Validation

Scientists of the Agricultural Research Service of the U.S. Department of Agriculture and Australia's Commonwealth Scientific and Industrial Research Organization, as well as modellers from other institutions, have agreed to cooperate with IBSNAT in the development and testing of simulation models for the ten IBSNAT crops. In order to successfully predict crop growth and yield over a wide range of environmental conditions in the lower latitudes, data combined from the minimum data sets collected from experiments conducted over a wide spectrum of agroenvironments will be used to develop the model for each crop. IBSNAT collaborators will test the validity of these models and observed discrepancies will provide useful feeback for refining or modifying the basic models.

In developing the simulation models it will be important to consider the nature and effects of the dynamic processes that operate in the soil. As these processes are reflected in the taxa of Soil Taxonomy, the simulation of agriculturally important processes that occur in the soil should be related to taxonomic soil classes. This is based on the realization that the numerical value of an individual soil parameter is meaningful only in relation to other

soil properties and that the effect of a given parameter varies with the taxonomic class of the soil. These relationships will be inferred from the carefully characterized soils of the IBSNAT sites and from many other benchmark soils collected and analyzed by the Soil Mangement Support Services. As the Benchmark Soils Project has shown, these relationships can by analogy be applied to taxonomically similar soils and can thus be used in simulation models. It is also planned to test the sensitivity of the models by using only data derived from various categoric levels of Soil Taxonomy. The purpose of that study is to determine how accurate crop performance predictions are if they are based only on the information contained, by definition, in the name of a taxon and on the covariant accessory properties.

Training in the Use of Models

The members of IBSNAT are primarily interested in using models to predict crop performance and to determine management inputs at new locations. They also want to be able to identify mismatches between crop requirements and land characteristics so that prescriptions for rectifying them can be recommended. And government planners may wish to employ agricultural models in the decision-making process.

In order to ascertain that the collaborators propitiously utilize the computer software developed and made available by the project, IBSNAT will conduct regional workshops to train collaborators in the use of systems analysis and agricultural models for their specific needs. The first training workshop will be held in Venezuela in December 1984.

Planning and Communication

IBSNAT has recently appointed a Technical Advisory Committee composed of internationally renowned scientists. This committee will be able to authoritatively guide and counsel the project regarding all technical matters. The collaborators themselves will have the opportunity to meet annually to report on progress, discuss problems, exchange experiences, and plan future work.

It is implicit in the IBSNAT philosophy that all data collected at the IBSNAT sites will, with the permission of the appropriate institution, be made available to all interested collaborators. A procedure to exploit the pooled knowledge generated by many research stations while, at the same time, preserving the research integrity of the data generators is now being worked out.

IBSNAT headquarter staff at the University of Hawaii will also develop mechanisms to keep collaborators and others informed about all relevant and developments and will establish communication links to allow the free exchange of data and ideas. A quarterly newsletter--Benchmark Sites News--will be published beginning in June 1984.

CONCLUSION

IBSNAT's main premise is that the transfer of agrotechnology can be achieved by simulating the performance of cultivars and agricultural processes and practices at the transfer site. While simulation models have long

been considered the conceptually best approach, various constraints have prevented their use in the past. Advances in crop modelling, however, coupled with advances in computer technology, now make such an approach entirely feasible. Huge amounts of data can now be processed quickly and translated in a purposeful way into user-oriented formats.

The IBSNAT methodology should allow to screen large numbers of technologies and cultivars relative to their suitability for transfer to various agroecological zones in the tropics and subtropics and to determine the management requirements to exploit their genetic potential at the new locations. The screening of technologies and cultivars by computer simulation cannot replace field research, but it enables the user to identify the technologies which, through a minimum of adaptive research, can be tailored to local conditions with a high probability of success.

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WHEAT AND BARELY MANAGEMENT IN JORDAN

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Background :

Geographically, Jordan lies between latitude 29:33 N and longitude 35:39E. The weather in general is mildly cold, during winter season, in which rain lasts for about four months, Nov-early April, and the other eight months are hot and dry.

Jordan has an area of about 92000 km² where 13% or about one million hectar is cultivated land. On the other hand 93% of the total cultivable land area is located under rainfed condition and about 60000 hectars are under irrigation mainly in the Jordan valley.

Agriculture in Jordan is considered the main element of the national income and about 10 % of the national income being based on agriculture. In-spite of this condition, the value of agricultural production is still short of satisfying domestic needs, except in case of lentiles where some of the production is yearly exported.

Field Crops :

Because of the adaptation of field crops to dry conditions, these crops are occupying most of the cultivated area as shown in table (1) .

From the table (1) we can say that both wheat and barely are the most domenant crops and occupying about 2/3 of the total cultivated area, and this due to their adaptation to dry condition.

Wheat and barely are the main crops in terms of both acreage and total gross value, but their area and production are varied from year to year as shown in table (2) .

Table (2) shows the wheat cultivated area, total production and average yield for the last eleven years 72-1982 .

Table (1) shows the average area planted in hectars and production in metric tons of main field crops, vegetables and fruit trees for six years 78-1982 .

TABLE (1)

CROPS	AREA/ha	PRODUCTION TONS
Field Crops :		
Wheat	113660	61200
Barely	51630	19500
Lentils	10330	6300
Vetch	3570	2200
Chick-peas	2160	2000
Vegetables :		
Tomato	11070	188700
Egg plant	2830	55400
Melons	5130	37800
Cucumbers	2960	38800
Broad Beans	980	6300
Fruit Trees :		
Olives	30290	29500
Grapes	2990	42900
Figs	200	900
Bananas	340	9900
Almonds	230	600

Table (2) shows the wheat and barely cultivated area in 1000 hectars, total production in metric tons, and average yield in kg/ha for the last eleven years 1972-1982 .

TABLE (2)

YEAR	WHEAT			BARELY		
	AREA 1000/ha	PRODUCTION M.ton	AVERAGE kg/ha	AREA 1000/ha	PROD. M.ton	AVERAGE kg/ha
1972	195.2	160.9	824	65.8	38.7	588
1973	136.5	37.7	276	41.0	5.7	140
1974	197.6	181.7	920	58.5	55.7	951
1975	140.1	61.9	442	39.6	14.7	371
1976	147.4	58.4	396	51.8	13.1	253
1977	131.2	56.0	427	44.1	13.6	309
1978	137.2	53.7	392	55.1	15.3	278
1979	93.4	16.4	176	40.2	6.7	167
1980	198.0	139.0	874	67.6	58.0	859
1981	106.1	59.7	563	44.8	18.2	405
1982	76.0	19.1	251	31.9	7.3	230
Average	138.0	76.8	504	49.0	22.5	415

As a result of these mentioned points that average yield of both wheat and barely are very low as shown in table (2) .

Table (3) shows that average yield of wheat and barely in Jordan compared to the average in certain locations in the world :

CROP	DEVELOPED COUNTRIES kg/ha	WORLD kg/ha	DEVELOPING COUNTRIES kg/ha	ARAB COUNTRIES kg/ha	JORDAN kg/ha
WHEAT	2084	1978	1370	903	504
BARELY	2320	1978	1248	764	415

Source seed processing feasibility study in Jordan ,(draft).

On the other hand the following figure shows that the average wheat yield in Jordan located in the first step (yield ladder) .

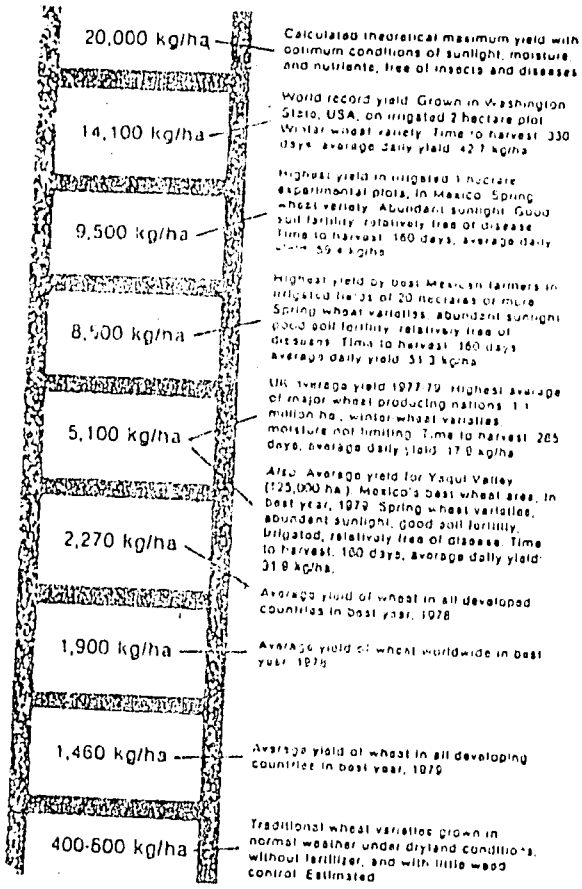

Figure 1. A productivity ladder illustrating a range of wheat yields from various environments and under various levels of management.

Source : Wheat in the third world.

From the previous table (2) we can drive the following facts :

1. The area, production, and average yield are fluctuated according to the total rainfall and its distribution .

2. The average yield is very low compared to other countries for the foll wing reasons :

   a) Both wheat and barely are planted in low rainfall areas(200-400mm/year)

   b) Traditional methods of farming are still in use .

3. Unavailability of sufficient amount of improved seed varieties to cover most of wheat and barely areas .

4. Unavailability of drought resistant varieties standing low rainfall .

5. Fertilizers and herbicides are considered as important factorsin increasing production, but the applications of both are very low for several reasons :

   i - High cost of these materials mainly fertilizers
   ii - Unavailability of these chemicals in the proper time.
   iii - Unavailability of application equipment mainly for herbicides,beside the absence of experience to use chemical weed control.

6. Unavailability of suitable equipment for seed bed preparation, where most of the farmers are using disc or malboard plow where both are not suitable for this type of cultivation. On the other hand chesil and sweep beside spring tooth harrow are the most equipment can fit this type of cultivation, mainly in semi-arid regions .

7. Rotations : as we know rotations are considered one of the main important factors of increasing crop production mainly under low rainfall . In fact, very few farmers are using rotation in their lands, where the majority are cultivating their land without following any type of rotation, mainly in

the marginal lands. But on the other hand in high rainfall region rotations are practiced either two or three years rotations .

8. Soil Plowing : Cultivation of soil is badly used in the hilly fields where most of the farmers plow their fields towards the slop and this way of cultivation is considered one of the main elements of soil erosion beside rainfall.

9. Land Fragmentation : Fragmentation of lands are one of the main problems facing agricultural development of production in Jordan table 4 . This situation stand as a barrier or obstacle, and in the same time prevent the use of suitable equipment in the correct way, and this refer to several reasons :

a) Samll holdings : 35% of land holdings are less than one hectar and 76% of land holding are less than five hectars .

b) Long narrow stripe of holdings force the farmers to plow their lands in one direction. and this form hard bans which affect the permeability of soil on the long run.

Table (4) shows the number of Agricultural holdings and area by size group :

TABLE (4)

Size Group/dunums	Number of Holdings	Area in dunums
Less than 5	8522	16038.9
5 - less than 10	3825	25679.2
10- less than 20	6929	92233.2
20- less than 30	5337	121890.5
30- less than 40	4666	150824.5
40- less than 50	2968	125914.4
50- less than 100	8634	570793.2
100- less than 200	5479	701828.7
200- less than 500	3359	933770.0
500- less than 1000	719	452125.3
1000- less than 2000	253	299725.5
2000- less than 5000	84	220487.5
5000- less than 10000	10	58920.0
10000- less than 25000	9	133800.0
More than 25000	-	-
TOTAL	50791	3904030.9

Wheat and Barely Improvement Efforts :

Crop improvement had started in Jordan in the last fifties but in a small scale due to the shortage of staff members and financial limitations But recently the work had expanded to cover most of the wheat and barely areas and in the same time the size of the work had also increased to develop the production of wheat and barely taking into consideration the following characters :

1. High yield capacity
2. Early maturing and drought resistant varieties

3. High protier and lysine content (still in the beginning stage).
4. Medium tall-tall varieties for low rainfall areas for mechanical combining .
5. Medium tillaring capacity with big heads
6. Resistant to disease mainly stem and leaf rust for high rainfall and irrigated regions.

To achieve these targets a big number of experimental trials are conducted yearly all over the country, where the activity includesthe followings :

1. Breeding work(crossing and selection)
2. Selection of promising lines from introduction
3. Testing of varieties
4. Fertilizer trials

Main Achievements :

As a result of research work that had been carried out in Jordan several wheat and barely high yielding varieties had been developed and released to be used by farmers.

Wheat varieties :

Deir Alla 1. Spring bread wheat variety developed from the cross (Gabo X PC 250) early maturing variety resistant to lodging and stem rust. Good yielding variety, medium tall, suitable for irrigated regions.

Deir Alla 2. Spring durum wheat variety, developed from the cross (houwani 27 x 1110/T;) suitable for low rainfall areas.

Deir Alla 4. Spring bread wheat variety selected from the line (1448/5081) and suitable for irrigated areas in the desert region, resistant to lodging and disease mainly stem and leaf rusts.

Barely varieties :

Dier Alla 102 . (ogalitsu) An introduced variety suitable for dry regions about 300 mm, of rain, medium tall, resistant to diseases mainly covered smut, lodging and shattering, six rowed type variety.

Dier Alla 106. This variety is considered the first barley variety that developed in Jordan from the cross (Arivat X Local D8) released in 1974. It has a wide adaptation to different climatological zones in the Near East and North Africa countries which is suitable for irrigation, high and low rainfall areas. The variety has a good characteristics such as yield, early maturity, resistant to lodging, shattering, and moderate resistant to diseases white kernal .

Recommendation for better wheat and barely production in dry regions :

1. Seed Bed Production :

Since most of wheat and barely areas are located in rainfall zones ranging between 200-450mm . Shallow plowing is recomended for those areas by using chisil and sweep followed by disc harrow to smooth the soil surface and this should be done during August and September.

2. Sowing :

a) Sowing date : Experimental results showed that best sowing date for wheat and barely under Jordan condition is during November and early December for certain areas.

b) Sowing depth : According to the research findings the best suitable depth for wheat and barely ranges between 6-8 cm where this depth prevent germination when there is only a little amount of rain, especially in the early season .

3. Seeding Rate :

Seeding rate is different from one location to other according to precipitation where in low rainfall zone the amount of seeds is less than that of high rainfall and we recommend the following areas :

	Low rainfall 250 - 300 mm	High rainfall 300 - 400 mm
Wheat	60 - 70Kg/ha	90 - 100 Kg/ha
Barley	50 - 60Kg/ha	70 - 80 Kg/ha

4. Fertilizers :

According to scarce and erratic rainfall farmers still hesitate to use fertilizers in wheat and barley fields . However, the results derived from the experimental research work showed that amount recommended for rainfall zones as follows :

Kg/ha

	250 - 300 mm		300 - 400 mm		above 400 mm	
	N	P_2O_5	N	P_2O_5	N	P_2O_5
Wheat and Barley	10	50	20	50	40-60	50

5. Weed Control :

As a fact weeds do compete wheat and barley in water, fertilizers, and air , they also are considered as a host for insects and diseases. To control these weeds, it is important to increase the production of both, and there are two ways to control the weeds :

a) Mechnical control:

Hand weeding , but this method cause some damage for the plants and also for root system and costly in same time

b) Chemical control :

This method is done in the early stages when the plant height is about 10-15 cm and after tellaring stage by 2.4.D, 2.4.5T, MCPA, etc.

In Jordan we found that 2.4.D is very good for controlling broad leaves in wheat and barley fieldsand at the same time has no side effect if spray is done in the correct time .

6. Rotation :

Under Jordan conditionsthe following rotation are used :

a) 250 - 300 mm of rain

First year	second year
Wheat & Barley	Follow

b) 300 - 400 mm of rain

First year	Second year
Wheat & Barley	Legumes & summer crops

c) Above 450 mm of rain

First year	Second year	Third year
Wheat	Summer crops	Legume

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REPLENISHMENT AND DEPLETION OF SOIL MOISTURE IN THE NORTHERN RAINFED AREAS OF EAST JORDAN

BY : A.M. BATTIKHI AND M. SAIMEH

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INTRODUCTION :

Water is a limiting factor for plant production in arid areas where water resources are limited. The total cultivable area in Jordan , is about five million dunums (5.7% of total area of Jordan) . An area, of about 4.9 million dunums, is under rainfed conditions .

In the farming areas of northern region of East Jordan the farmers generally use a three year crop rotation (fallow - wheat - Summer crop). The production of wheat per unit area in Jordan is very low compared to the production of wheat in other countries. The average production was 41.5 Kg/dunum in 1978, whereas the average production in United States during that year was 212.8 Kg/dunum . Wheat crop requires about 150 mm of rainfall before it reaches the flowering stage, provided all other conditions are optimum. Each additional millimeter of rain is believed to produce one kilogram increment of wheat per dunum. This means that for an area of about 500,000 dunums planted with wheat, if one millimeter of rainfall is conserved a total increase in production of about 500 ton of wheat could be attained. In order to increase wheat production in these lands it is necessary to study their water regimes.

A two years study was carried out in Irbid district soils representing soil series 11, 15, and 31 . The objectives of the study were to determine the exact amounts of water stored in the root zone due to precipitation, and to determine the depletion occuring in that zone due to evapotranspiration

by wheat and summer crops as well as the effects of fallow on moisture conservation . It was also intended to study the effects of slope classes on moisture retention and depletion.

LITERATURE REVIEW :

Some studies were made to know how much of the rainfall water will be stored in the soil and used by the plants. Hopkinson (1975) found that wheat plants extract soil moisture from depths more than 150 cm in Karak region in Jordan . Also he found that lentil consumes less amounts of water than wheat, In the fallow plots he found that it is possible to store up to 80 mm of the available water in the top meter of the soil together with an additional quantity of about 50 mm between loo and 18o cm depth .

Mathews and Army (1960) summerized soil moisture data from 25 stations in the great plains in U.S.A. , and reported an average of only 16%, of the total precipitation was stored in the soil during the fallow period. However, more moisture was generally conserved in the northern than southern great plains.

Singh and Russel (1979) found that during monsoon season, water losses by evaporation, transpiration, and drainage constituted 21, 35, and 29% respectively, of the total seasonal available water (Rainfed + irrigation + profile available water) and in the post- monsoon, the only unproductive loss of water was soil evaporation which formed one-fourth of the total seasonal available water. The major amount of moisture depletion during the post monsoon season was confined to the top 90 cm profile depth.

Lucbs and Laag (1971) compared in California three crop water management systems for barley in winter rainfall climate on sandy loam soil. they were :

1) annual cropping with runoff retention .
2) a fallow crop sequence with runoff retention.
3) induced runoff on one half of the area for the concentration, and annual cropping in the remaining half.

Over three year period average grain yields were 1.58, 2.14, and 2.29 ton/ha. for annual cropping, fallow-crop, and induced runoff concentration systems, respectively . The additional soil water in the down slope areas of the annual and follow -crop systems and in areas receiving induced runoff reflected in increased barley kernels per head and greater kernel weight.

Holding runoff on the land and cropping annually increased rainfall use efficiency by 42% over both, that obtained where runoff occurred in the annual cropping system and that obtained for the entire plot area in the follow-crop system. The efficiency of fallow for storing water in the soil was 16.7%

Tamimi (1979) found that deep plowing in Hamam Al-Alil (Iraq) before rainfall does not improve moisture storage in the soil. It was noted also that the largest soil moisture loss from depths studied (15, 30, and 45cm) took place in May. Therefore he concluded that all conservation methods must be done before this time. Data on soil moisture also revealed that about 3 mm of effective rainfall (in Dec. , Jan, Feb) will be needed to wet a depth of about 1 cm of soil.

Loizides (1979) found in his studies that in the mediterranean region, fallow does not necessarily result in any significant increase in the amount of water available to plants for the next season. At sowing, the crop has to rely entirely on rain. He also found that, at the onset of rapid growth in March, the water content of the root zone, to a depth of 80-90 cm or more, is the same irrespective of whether the land was cropped or left under fallow during the proceeding season.

Handal and De Datta (1982) found that by starting with initial moisture content close to field capacity, maximum water depletion of 248. 86, 55 35, and 58mm occured in the weedy control, bare soil, straw mulch, plowed and rotovated, and rotovated treatments, respectively at the end of the dry season.

Greb and Smika, 1979, reported that wheat requires 220mm of water for evapotranspiration in the Central Great Plains of U.S. for initial grain development . Yields then increase 105-185 Kg/ha/cm water . They listed 5 requirements to improve moisture conservation in a wheat- fallow system. They are :

1. Weed control, where production of 1120 Kg/ha weeds consumed about 7.6 cm/ha.

2. Standing stubble over winter, where 35-55% increase in moisture storage took place from snowmelt in stubble.

3. Straw mulch, where water storage increased by 5 cm when mulching was increased from zero to 6.6 ton/ha.

4. Keeping soil clods which resist wind erosion , slow down runoff, provide shade, and physically protect young plants.

5. Seedbed water, improving management of seed zone water by mulching by using modern deep furrow planters (12-14cm) to place seeds in wet soil so as to enhance germination.

MATERIALS AND METHODS :

1. Location :

The study was conducted in Irbid region within the areas of Hawara, Bishra, and Assarih Villages. The exact locations were selected on the basis of the availability of different soil series in the area and the kind of crops planted as well as its closeness to Irbid Meteorological Station. Figure(1) shows the exact locations of the selected sites .

2. Soil :

Soils were selected to represent three series as classified by the soil survey team of the Ministry of Agriculture (1970) namely 11, 15 and 31. Two slopes were selected from each soil series . These slopes are : From zero to 3% designated by slope A ; and from 3 to 8%, designated as slope B.

3 Soil Moisture Measurements :

The neutron probe (hydroprobe, Model 503) was used to measure moisture content at different depths.(Fig 1) shows the locationsof the access tubes. Twenty access tubes were installed in twenty places in the farmers fields distributed as shown in fig 1 .

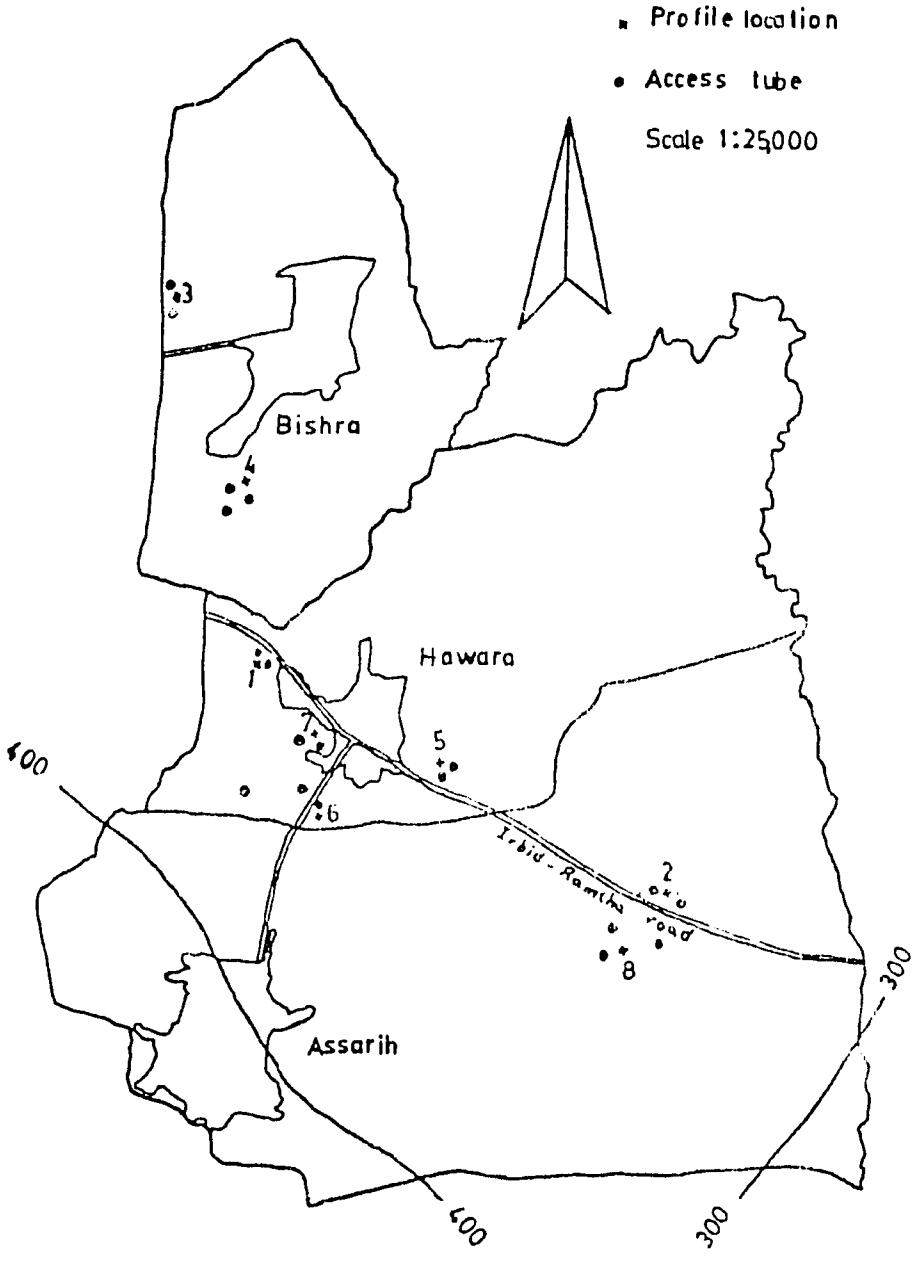

Fig.1, Map showing the locations of the study areas.

Holes for tubes were dug by using a two-inch diameter (I.D.) auger. Then pipes (120 cm long) were inserted into holes, leaving 10 cm of the tubes above the soil surface.

The measurements were taken at depths of 0, 10, 25, 40, 55, 70 and 85 cm to represent the following respective layers.

Reading depth (cm)	Layer depth (cm)
0	0 - 5
10	5 - 17.5
25	17.5 - 32.5
40	32.5 - 47.5
55	47.5 - 62.5
70	62.5 - 77.5
85	77.5 - 92.5

4- Calibration Curve :

The calibration curves for all soil ,series were obtained by taking soil moisture counts and soil moisture samples for gravimetric moisture measurements using the two-inch diameter auger for depths of 10, 25, 40, and 55 cm around the access tubes. Samples were collected all year round, once every two weeks.

Readingsat 10 and 25 cm were used to draw the calibration curves of the soil surface , for each soil series , and at 40 and 55 cm to draw the calibration curves for subsurface soil .

TABLE (1) : Some physical properties of soil series 11. Site number 4, in Irbid district.

DEPTH (cm)	BULK DENSITY (gm/cm^3)	% PARTICLE SIZE DISTRIBUTION			TEXTURAL CLASS
		Clay	Silt	Sand	
0-10	1.03	51.67	40.93	7.40	Sic
10-30	1.31	60.64	32.16	7.20	C
30-55	1.24	61.23	31.17	7.60	C
55-80	1.30	64.35	25.25	10.40	C
80-100	1.19	67.85	19.14	13.01	C
100-130	1.31	62.98	23.62	13.40	C

Palexerollic Chromoxerert, fine, montmorillonitic , thermic. Reddish brown to yellowish red, clayey, developed on hard limestone , associated with variable amounts of chert, compact, shrinking in the dry season, strongly developed structure, with calcium carbonate concretions in the subsoil.

TABLE (2): Distribution of access tubes in the fields and the cropping practices in each location for the seasoning 1979/80 and 1980/81.

SERIES	SITE NO.	CROP 79/80	CROP 80/81
11 A	1	Fallow	Fallow
11 A	2	Summer crop	Wheat
11 A	3	Summer crop	*
11 A	4	Wheat	*
11 B	5	Wheat	Fallow
11 B	6	Summer crop	Wheat
11 B	7	Fallow	Fallow

* Readings were not taken during the second season 1980/81 due to the continuous removal of the access tubes by unknown persons.

where :

A = slope from 0-3 %

B = slope from 3-8 %

TABLE (3) : Some physical properties of soil series 15

DEPTH (cm)	BULK DENSITY (gm/cm^3)	% PARTICLE SIZE DISTRIBUTION			TEXTURAL Clas
		Clay	Silt	Sand	
0-5	1.08	55.18	35.02	9.80	C
5-30	1.13	71.37	22.63	6.00	C
30-52	1.30	69.81	22.99	7.20	C
52-80	1.28	76.31	15.26	8.43	C
80-110	1.34	74.93	21.03	4.04	C

Palexerollic chromoxerert, very fine, mixed, thermic. Reddish brown to yellowish red, clays, developed on hard limestone associated with basalt, compact. It forms moderately wide cracks in the dry season and strongly developed structure with calcium carbonate concretions in the subsoil.

TABLE (4) : Distribution of access tubes in the field

SERIES	SITE NO.	CROP 79/80	Crop 80/81
15 A	1	Fallow	Fallow
15 A	2	Lentil	Fallow
15 A	3	Fallow	Fallow
15 A	4	Wheat	*
15 B	5	Tobacco	*
15 B	6	Wheat	Fallow
15 b	7	Fallow	Fallow

* Readings were not taken during the second season 1980/81 due to continuous removal of the access tubes by unknown persons.

Where :

A = slope from 0 - 3%

B = slope from 3 - 8%

TABLE(5) : Some physical properties of soil series 31

DEPTH (cm)	BULK DENSITY (gm/cm^3)	% PARTICLE SIZE DISTRIBUTION			TEXTURAL CLASS
		Clay	Silt	Sand	
0-15	1.07	52.44	28.79	18.77	C
15-40	1.26	68.40	18.47	13.13	C
40-80	1.37	63.37	18.82	17.81	C
80-120	1.33	61.42	21.34	17.24	C

Typic chromoxerert, fine montmorillonitic, thermic. Reddish brown to yellowish red, clay loam, good structure, developed on hard limestone associated with variable amounts of chert.

TABLE (6) : Distribution of access tubes in the field

Series	Site No.	Crop 79/80	Crop 80/81
31 A	1	Wheat	Fallow
31 A	2	Wheat	Fallow
31 A	3	Wheat	Fallow
31 A	4	Fallow	Fallow
31 B	5	Wheat	*
31 B	6	Wheat	Fallow

Where :

A = slope from 0 - 3%

B = slope from 3 - 8%

* Readings were not taken in the second season due to the continuous removal of the access tubes by unknown persons.

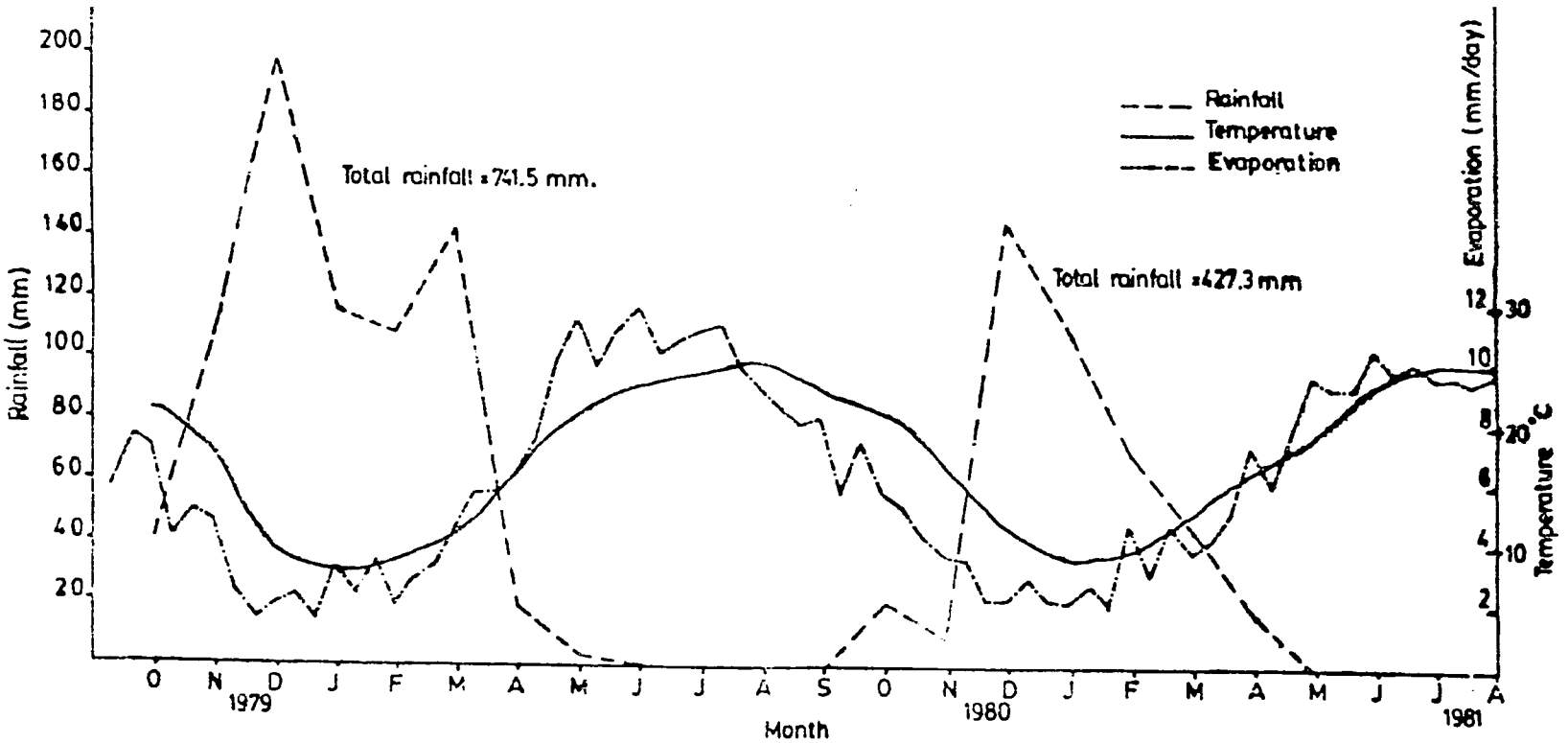

Fig.2. Rainfall amounts, mean monthly temperature, and evaporation (10 days mean) in Irbid region during the period Oct, 1979 - Aug, 1981 .

TABLE (7) : Soil moisture storage and depletion in the upper 92.5cm (total per season , and % of total rainfall)* for uncropped sites in the northern regions of East Jordan

Profile	Moisture stored				Moisture depleted			
	1979/80		1980/81		1979/80		1980/81	
	(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)
11 A1	155	20.9	110	25.7	143	19.2	-	-
11 B1	-	-	147	34.4	-	-	-	-
11 B3	162	21.8	123	28.8	142	19.2	-	-
15 A1	109	14.7	75	17.6	144	19.4	118	27.6
15 A2	-	-	131	30.7	-	-	91	21.3
15 A3	138	18.6	142	33.2	208	28.1	120	28.1
15 B2	-	-	130	30.4	-	-	-	-
15 B3	129	17.4	131	30.7	135	18.2	-	-
31 A1	-	-	97	22.7	-	-	54	12.6
31 A3	-	-	121	28.3	-	-	89	20.8
31 A4	168	22.7	106	24.8	182	24.5	85	19.9

* Total rainfall in the area during 1979/80 was 741.5 mm, and during 1980/81 was 427.3 mm

TABLE (5) : Soil moisture storage and depletion in the upper 92.5cm (total per season and until harvest time) for wheat planted sites in the northern regions of East Jordan, expressed in mm and as % of total rainfall

Profile	Moisture stored				MOISTURE DEPLETED							
					Total		Until harvest (c.u.)		Total		Until harvest (c.u.)	
	1979/80		1980/81		1979/80		1980/81		1979/80		1980/81	
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%
11 A2	-	-	126	29.5	-	-	-	-	199	46.6	137	32.0
11 B1	185	25	-	-	218	29.4	200	27.0	-	-	-	-
11 B2	-	-	95	22.2	-	-	-	-	74	17.3	72	16.8
15 A1	-	-	-	-	187	25.2	148	22.1	-	-	-	-
15 B2	147	19.8	-	-	209	28.2	182	24.5	-	-	-	-
31 A1	132	17.8	-	-	182	24.5	171	23.1	-	-	-	-
31 A2	147	19.8	-	-	211	28.5	140	18.9	-	-	-	-
31 A3	164	22.1	-	-	187	25.2	166	22.4	-	-	-	-
31 B1	163	22.1	-	-	180	24.3	174	23.5	-	-	-	-
31 B2	158	21.3	-	-	204	27.5	180	24.3	-	-	-	-

* Total rainfall in the area during 1979/80 was 741.5 mm, and during 1980/81 was 427.3 mm

TABLE (9) : Soil moisture storage and depletion (total per season and until harvest time) for water melon, tobacco and lentil planted sites in the northern region of East Jordan

PROFILE	Moistured Stored (1979/80)		Moisture depleted (1979/80)			
			$d_{max} - d_{min}$		unitl harvest	
	mm	(%)	mm	(%)	mm	(%)
11 A2 Water-melon	142	19.1	196	26.4	175	23.5 *
11 A3 water-melon	151	20.4	143	19.3	127	17.1 *
11 B2 Water-melon	160	21.6	142	19.2	141	19.0 *
15 A2 Lentils	115	15.5	183	24.7	-	-
15 B1 Tobacco	105	14.2	152	20.4	122	16.4**

* March 1st - Spet 15

** May 2 - Sept. 21

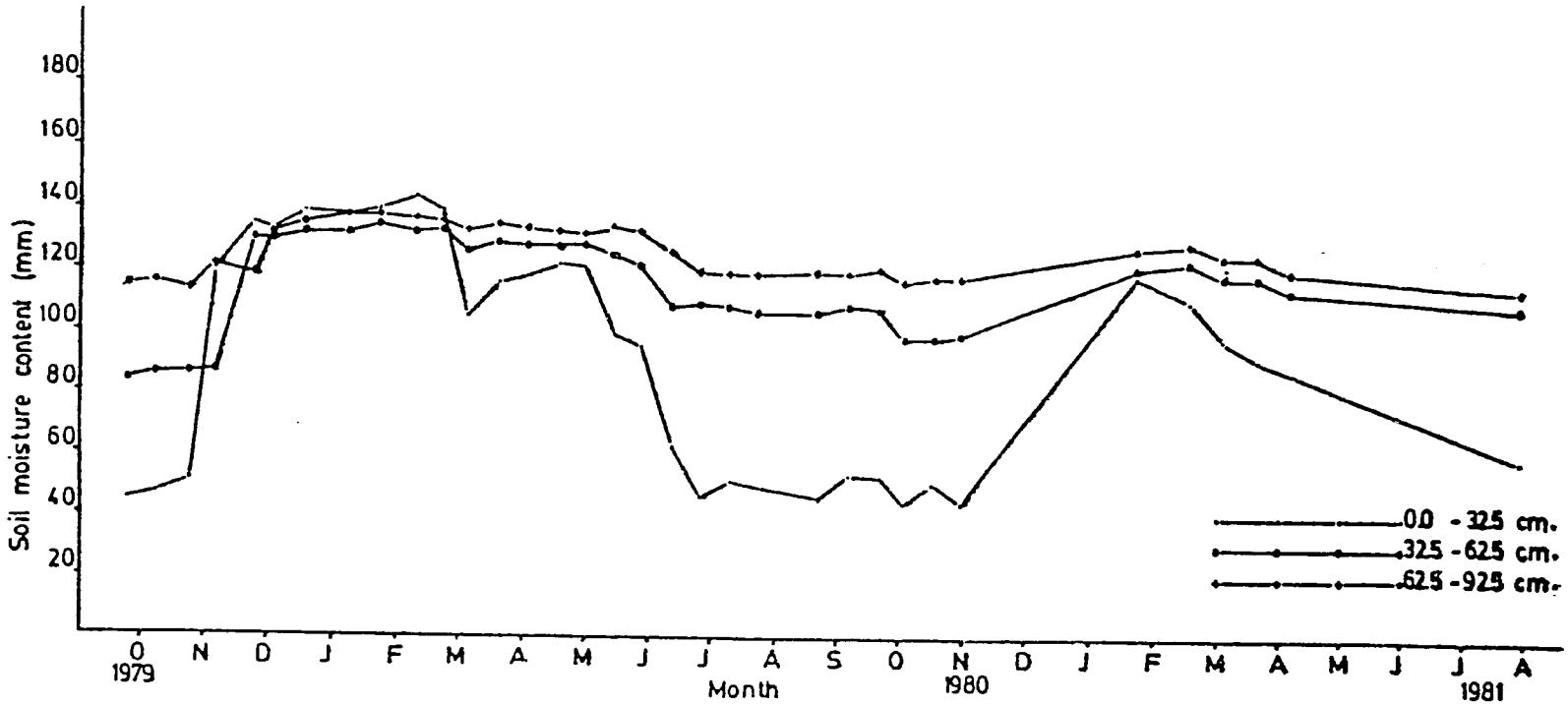

Fig. 3 . Soil moisture content in location 2 (soil series 11, slope, B) for the different layers of soil using crop rotation summer-crop-wheat .

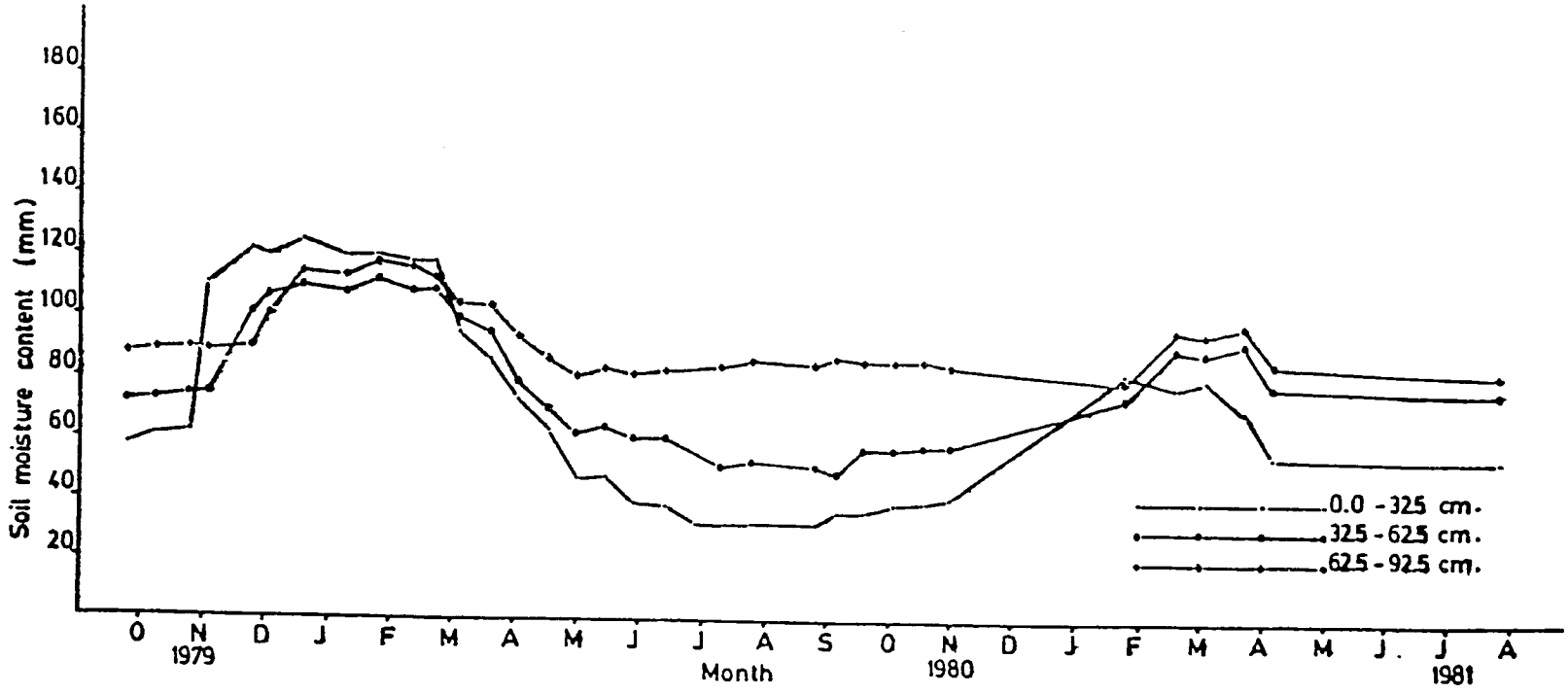

Fig. 4 . Soil moisture content in location 9 (soil series 31, slope A) for the different layers of soil using crop rotation wheat-follow.

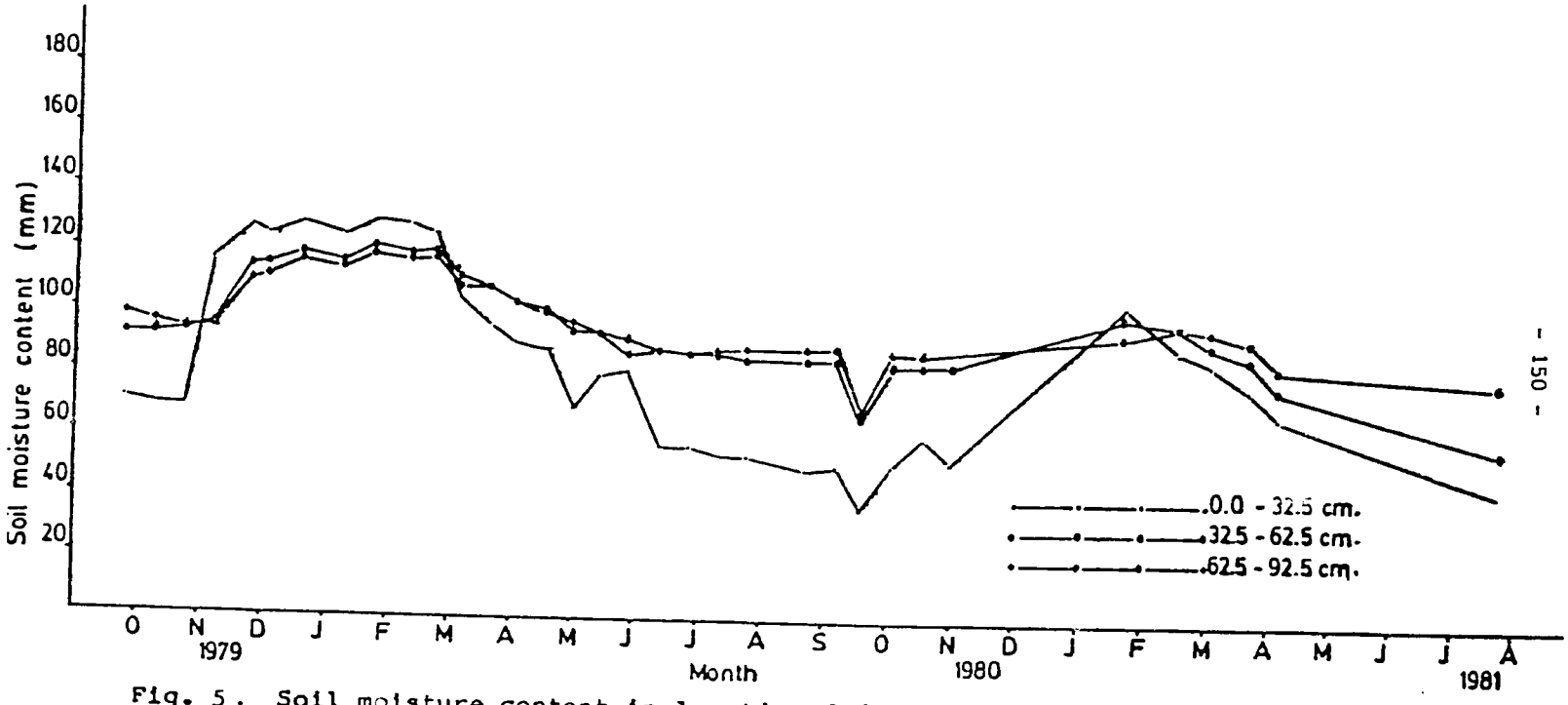

Fig. 5. Soil moisture content in location 6 (soil series 15, slope A) for the different layers of soil using crop rotation fallow-fallow.

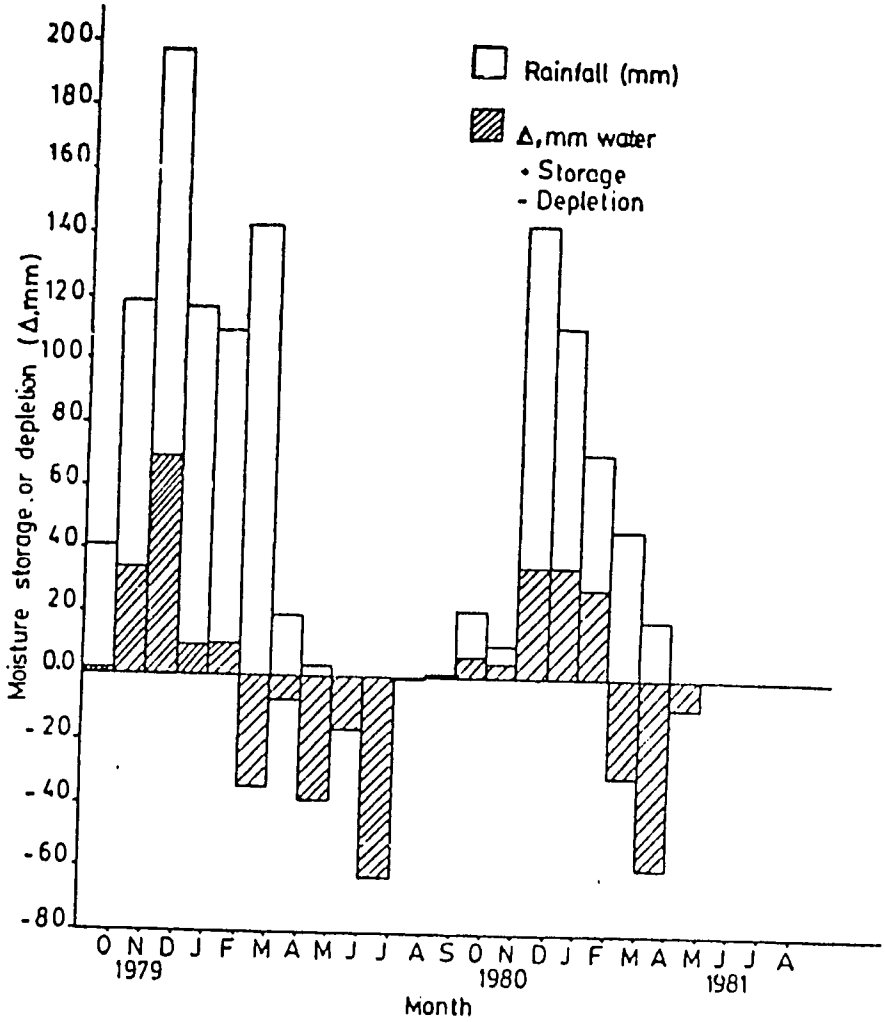

Fig. 6 . Monthly soil moisture storage and depletion (mm/77.5cm depth) in location 5 (series 11 slope A, Summer-crop-wheat) from Oct, 1979 . April, 1981 .

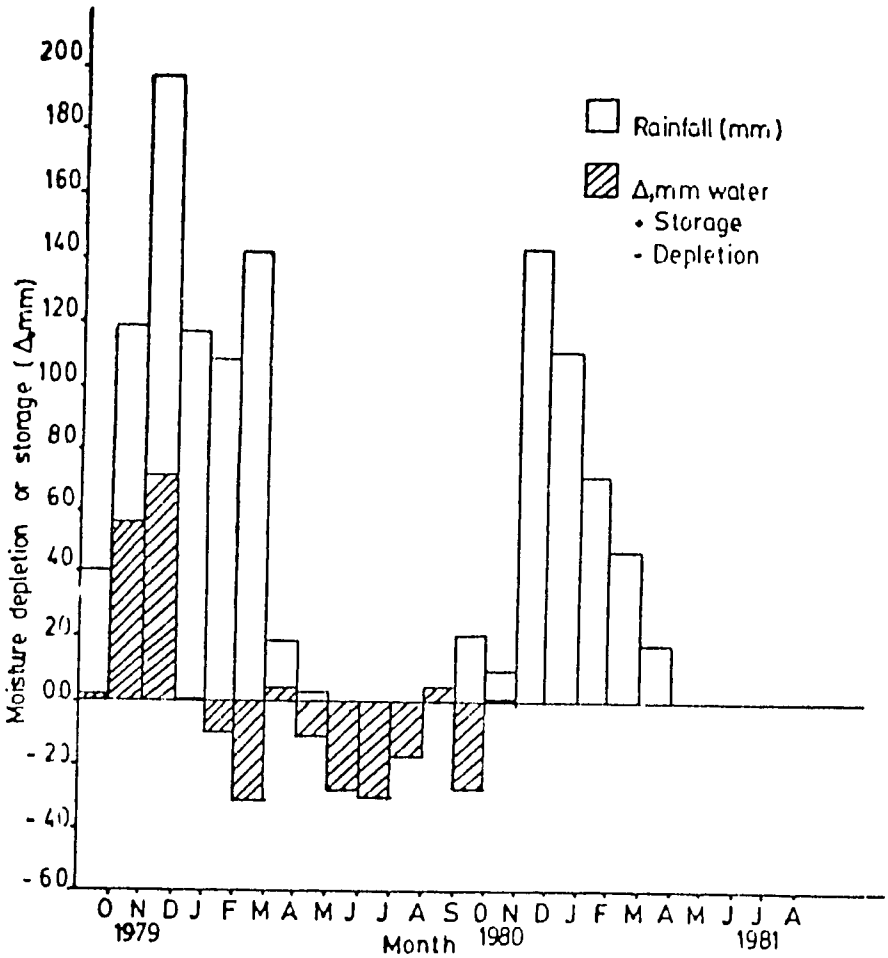

Fig. 7. Monthly soil moisture storage and depletion (mm/77.5 cm depth) in location 14A (Series 11, slope A, Summer - crop) for the period Oct 1979 - Nov. 1980 .

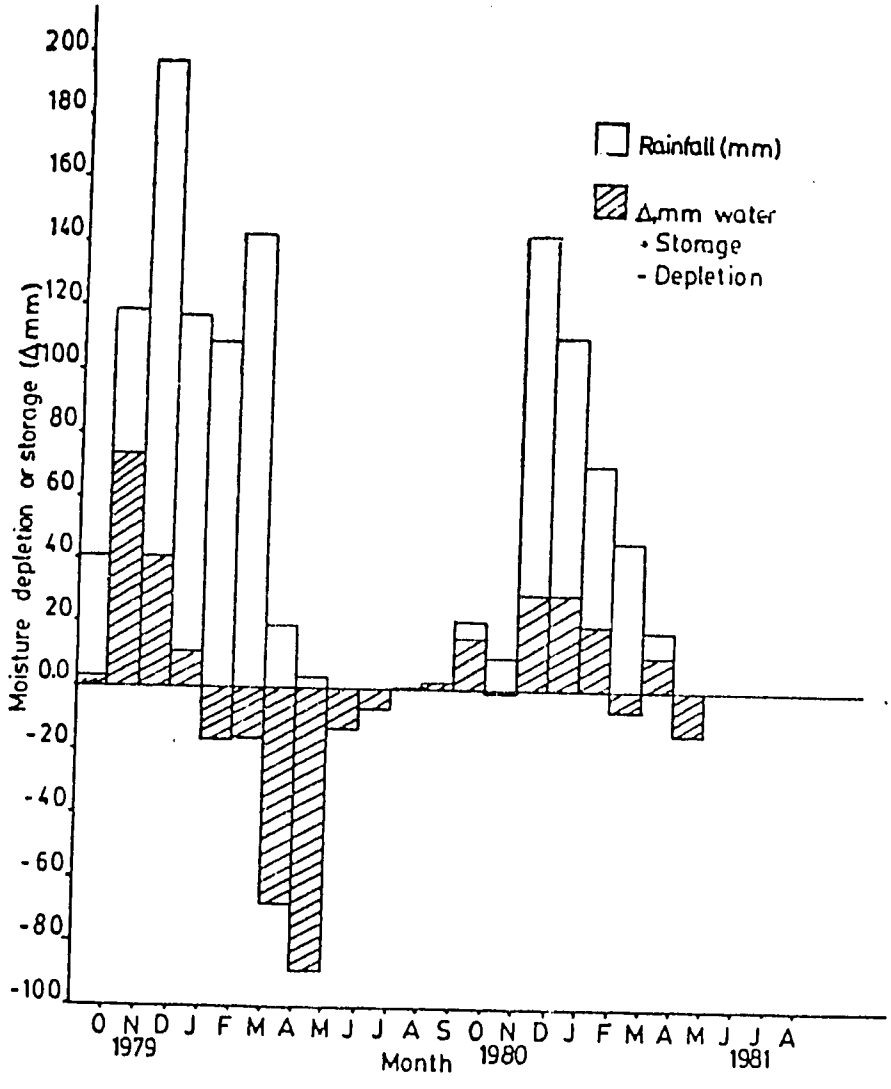

Fig. 8. Monthly soil moisture storage and depletion (mm/77.5cm.depth) in location 1 (series 11, slope B, wheat - fallow) for the period : Oct, 1979 - May 1981.

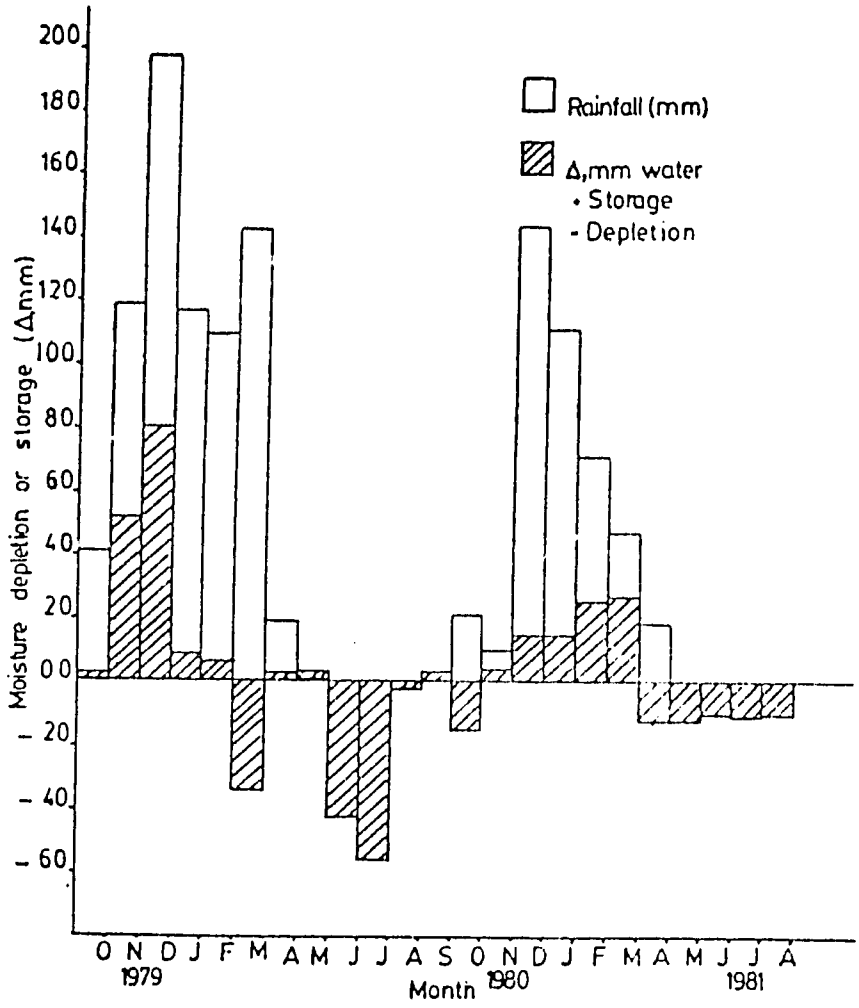

Fig. 9. Monthly soil moisture storage and depletion (mm/77.5 cm.depth) in location 2 (series 11, slope B, summer - crop - wheat) for the period: Oct, 1979-Aug, 1981.

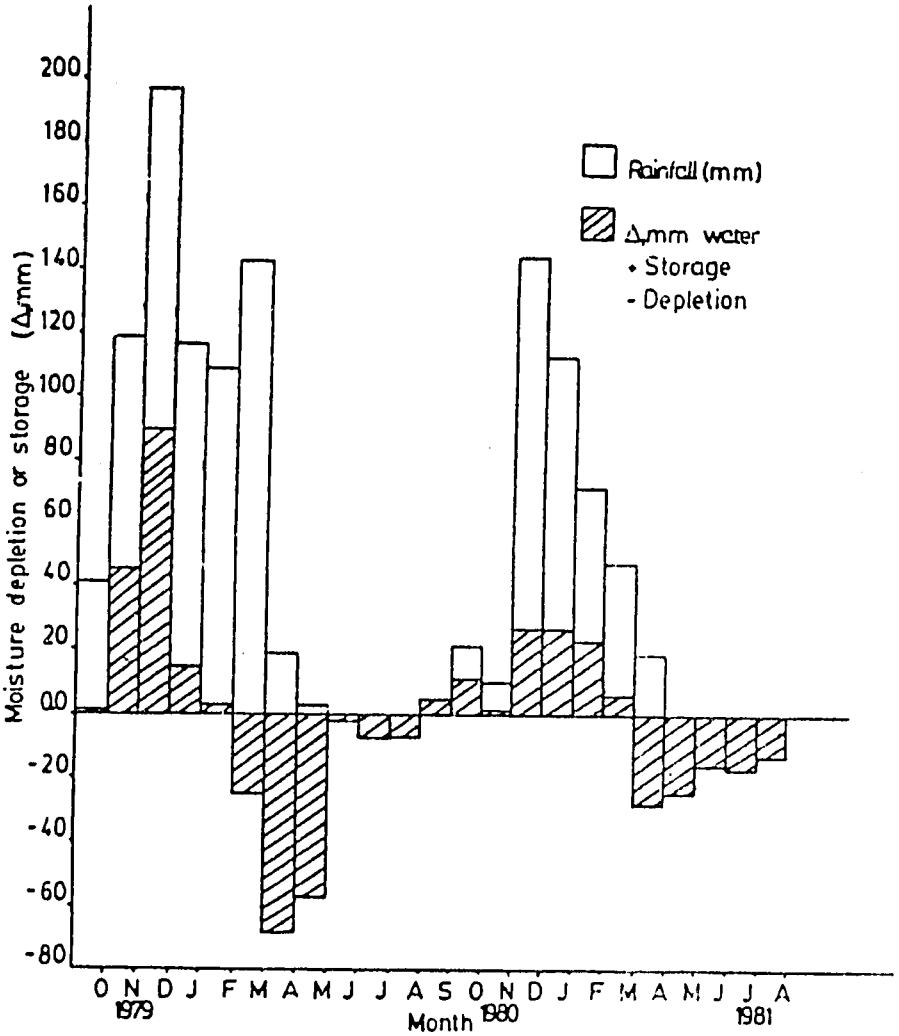

Fig. 10. Monthly soil moisture storage and depletion (mm/77.5 cm depth) in location 11 (series 31, slope A. wheat, fallow) for the period : Oct, 1979 - Nov, 1981.

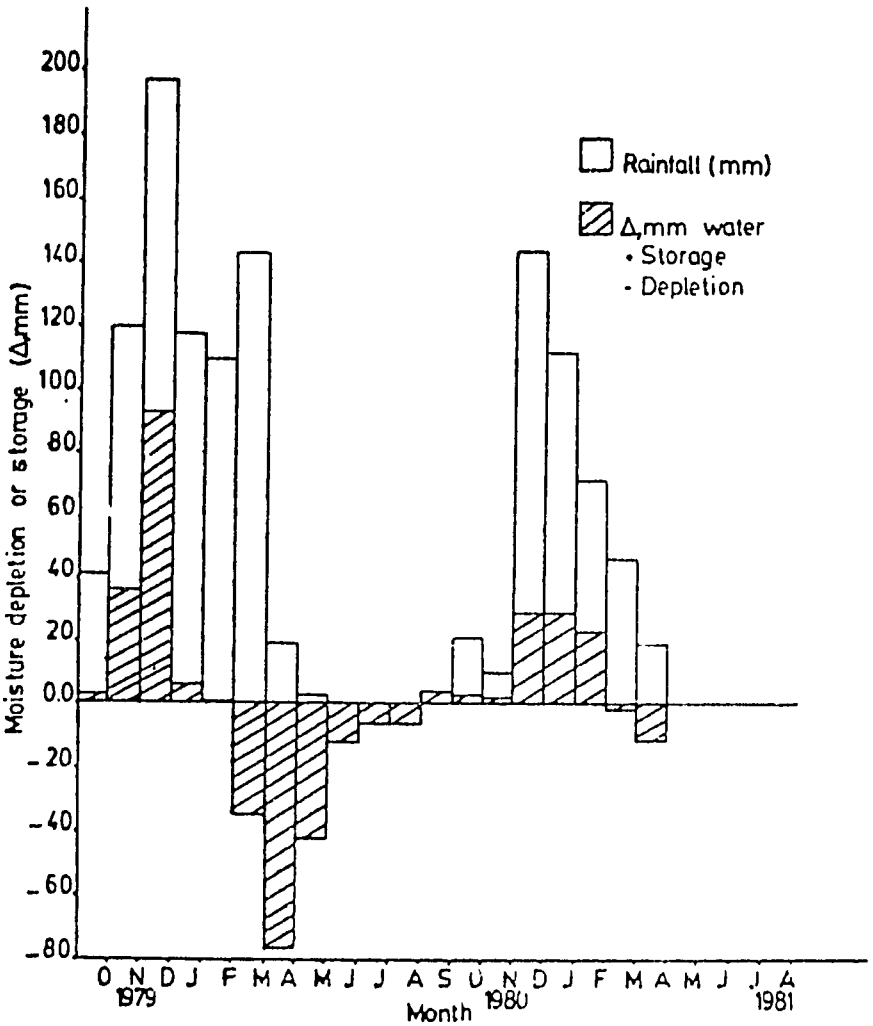

Fig.11. Monthly soil moisture storage and depletion (mm/77.5 cm depth) in location 12 (series 31, slope B. Wheat - Fallow) for the period: Oct, 1979 - April, 1981.

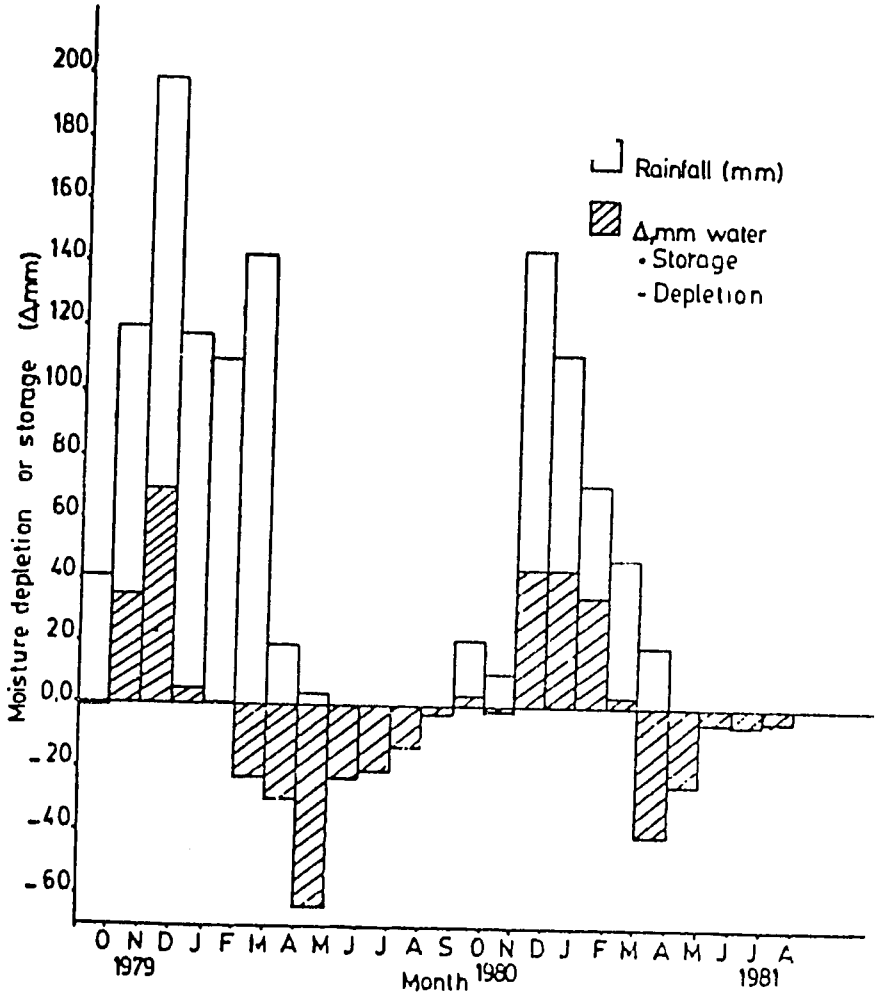

Fig.12. Monthly soil moisture storage and depletion (mm/77.5cm depth) in location 7 (series 15, slope A, lentil - fallow) for the period: Oct, 1979 - Aug, 1981 .

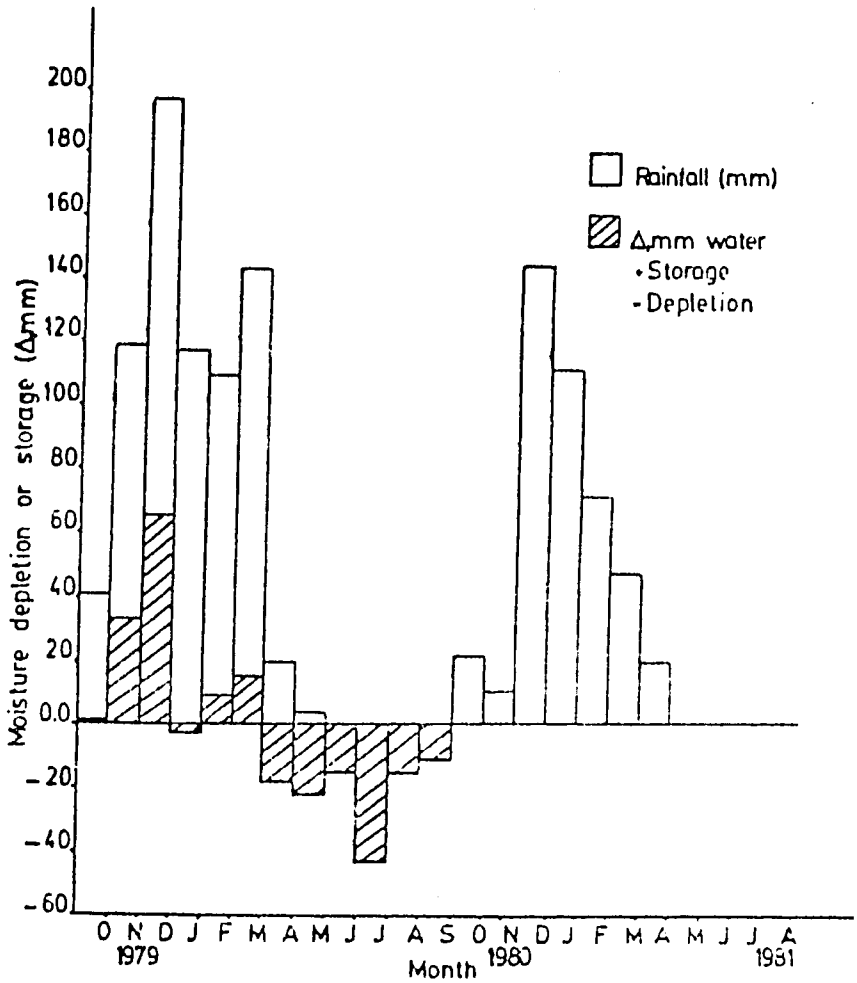

Fig.13. Monthly soil moisture storage and depletion (mm/77.5 cm depth) in location 15 (series 15, slope B, Tobacco) for the period: Oct, 1979 - Oct, 1980 .

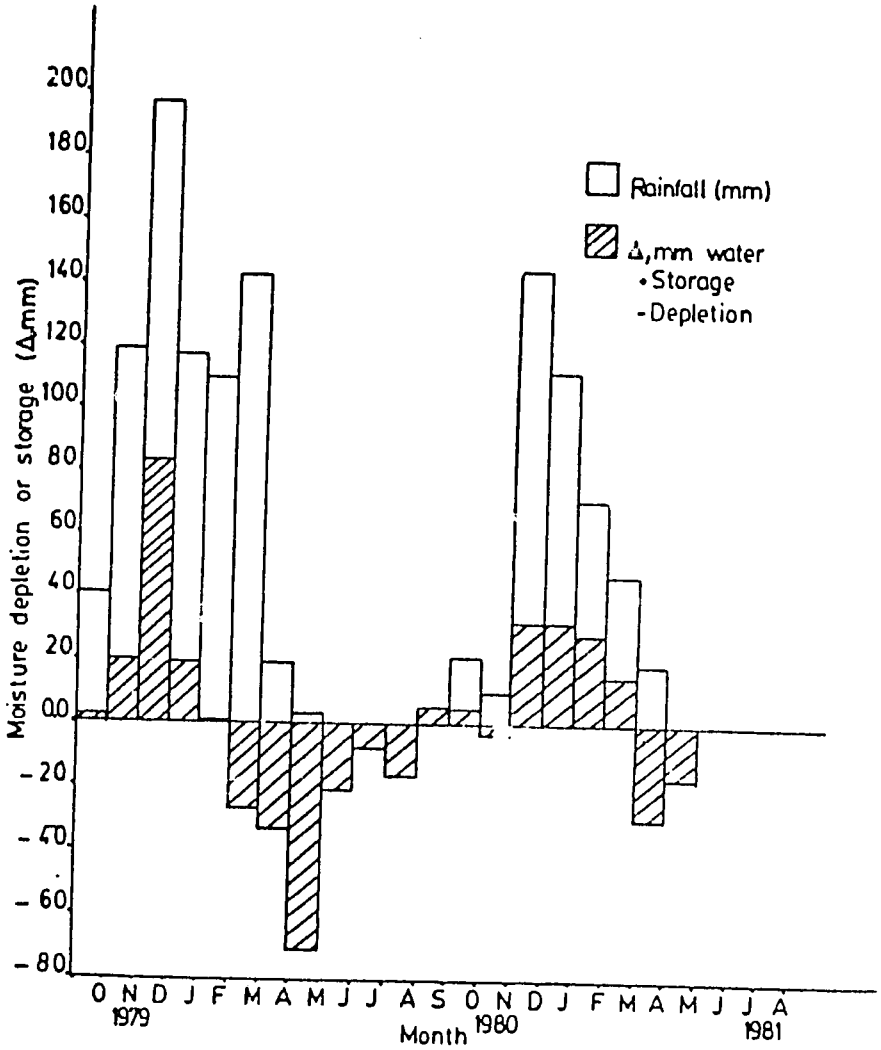

Fig.14. Monthly soil moisture storage and depletion (mm/77.5 cm depth) in location 16 (series 15, slope B, wheat - fallow for the period : Oct, 1979 - May, 1981 .

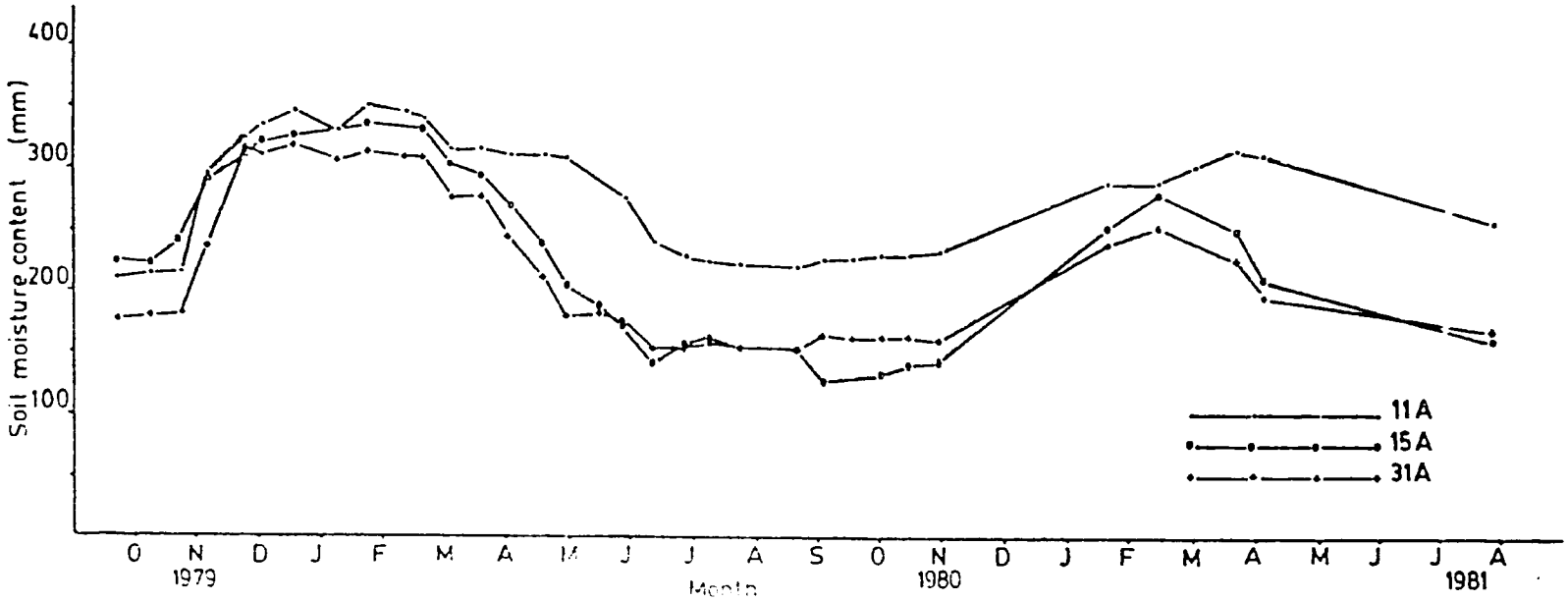

Fig.15. The difference in soil moisture content between the three soil series, slope A.

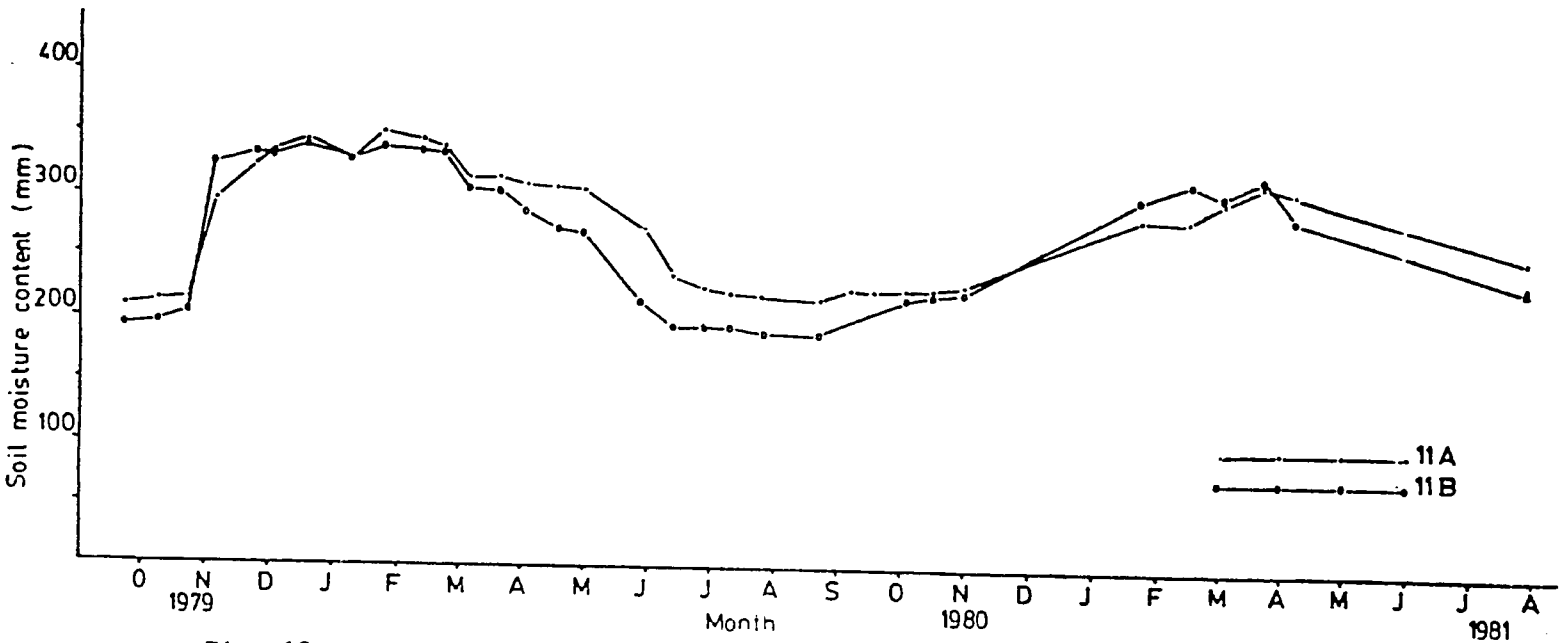

Fig. 16. The difference in soil moisture content between two slopes A, and B in soil series 11 .

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AGROTECHNOLOGY TRANSFER IN THE ARAB COUNTRIES UNDER RAINFED AGRICULTURE

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INTRODUCTION :

Population in the Arab countries is expected to increase by fifty per cent by the end of century; and can consequently crop production in food and fiber should increase proportionally to meet the human requirements. Otherwise, shortage is expected to be the main problem facing the Arab world.

During the present century, a tremendous amount of human knowledge in science and technology has been accumulated. That would include the agricultural technology as well . Concerning the Arab world, it has benefited, since the end of Second World War especially, from new discoveries in field of crop production and others. The domaine of irrigated agriculture has enjoyed the greatest interest from the part of the Arab Governments and farmers. Improved varieties of several crops were introduced such as cotton, hybrid corn, suger beet, Mexican wheat, soybean and others. Chemical fertilizers were imported and used by farmers ; and several Arab countries have built their own fertilizer factories . Fertilizer consumption at the national level had increased steadily in the last thirty years, however, the level of fertilizer use in most Arab countries is still far below the adequate level necessary for a maximum crop production. Machines, tools and vehicles necessary for land preparation, harvesting , transport, crop processing and others were introduced in all Arab countries. Chemical compounds to control insects , disease and

weed were widely used by Arab farmers, although sometimes with inadequate efficiency . New methods in irrigation system were used efficiently by Arab farmers such as the sprinkler and drip irrigation . Most recently, plasticulture has become a wide used technique for vegetable production in remote area where land is lacking or available water is short.

Complete success in the introduction of new technology into irrigated agriculture in the Arab Countries was not always the rule ; and the chances are still open to increase significantly crop production, by application of new technology and results obtained under compatible and similar environmental conditions. Technology transfer was not always possible in many cases due to some local difficulties , such as the availability of well trained scientists, the efficiency of extension services, the adequate use and availability of equipments and tools and finally the available funds.

Rainfed agriculture represents eighty per cent of the total cultivated area of the Arab World. That made the intensity of cropping low and the average yield per hectar is in the vicinity of 1.1 ton; with cereals as the main production occupying 68% of the total rainfed lands. Wheat and barley represent the main cereal cultivated crops. The potential productivity of rainfed agriculture in the Arab countries has been in general underestimated ; and transfer of new technology has been poor in general and little attention was given to the study of main factors affecting rainfed production . Constraints to increased production were attributed to different factors such as the lack of available moisture which stands as the most limiting factor affecting cereal production. Other factors were considered to affect yields. Soil nutrients availability , soil and water conservation system used by the farmers, the soil management practices , the use of chemical fertilizers, weed and disease control were all or some cited as contributing variables to low yields. The organizational aspects and pricing policy, credit , marketing facilities and all factors affecting the input/output relationships would not be underestimated as factors affecting to a large extent the development of rainfed agriculture.

Cereal production in the Arab countries which is mostly concentrated in the rainfed area, oscillates within large intervals from one year to the next. That is mainly due to changes in yields of crops per unit area, and to

some extent to total cultivated area as well . Disturbance in crop production could be due to climatic as well as to soil characteristics and it is only through the understanding of the inter-relationships between crop production in the rainfed area, climate, soil properties and farm management practices that it becomes possible to identify the management system that will maximize production and to determine the factors that should be controlled to improve productivity through agrotechnology transfer, as well as creating means to make prediction on fields of crops and estimation of climatic risks in crop production.

The present article will summarize the three years results obtained in a regional project, carried out by the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) which is initiated in 1979-80 to study cereal production as related to climate, soil and management variables using a multiple regression computer program. The program started in a pilot area of Syria and is extended since 1981-82 to three other Arab countries which are Jordan, Morocco and Algeria .

The main goals of the project are :

1. Study of the inter-relationships between yields of rainfed crops and especially wheat and barley and the basic properties of soil, climate and management variables .

2. Establish an adequate method to define and determine the most important variables that affect significantly yields of rainfed crops with the contribution of each variable and effect on yields.

3. Elaborate practical regression models with the minimum number of data set to forecast crop production of rainfed soils where technology factors are included in the modles allowing the prediction of yield increase with the transfer of new technology .

4. The application of regression models to help in classifying agricultural soils of the Arab countries into homogeneous classes of potential productivity for rainfed crops; and consequently the determination of marginal areas that could be developed .

Preview Works in the Arab Countries and Elsewhere :

Several researchers in the Arab countries tried to relate yield of cereals to one or more of climatic variables . Gangopadhyaya and Zaki (4) in Iraq related yields of wheat to total annual rainfall and mean air temperature. In long-term study, Matar(8) related yields of wheat and lentil grown at Izraa Experimental Station in Syria, to rainfall in various parts of the growing season. Total precipitation in December and January showed the highest correlation with yield of wheat (R = + 0.95) . Simaka (12) found in Jordan that intensity of rainfall during Dec. through Feb. the best variable to make prediction on wheat yield within reasonable confidence limits. Kawasma (6) later related yield of wheat to total rainfall from emergence to heading and to maximum and minimum temperature at certain critical physiological stages of wheat growth.

Several scientists predicted yields of wheat from measurement or estimation of soil moisture. Haun (5) derived equations to relate yields of spring wheat to a growth index calculated from the max. and min. temperatures and measured available soil moisture. Baier and Robertson (1) in Canada used available soil moisture in the root zone which was estimated from meteorological data, to make significant prediction on grain wheat yields.

Soil parameters and management variables were introduced into regression models in addition to precipitation or available soil moisture, to make prediction on yields of wheat. One could cite the works of Feyerhem and Paulsen (3) who developed regression models to predict wheat yield in the wheat belt of the United States , using weather elements, some soil properties such as drainage conditions, texture and some significant episodic events. Reddy et al (10) used multiple regression type computer programs, where several soils, crop and climate data bases are being interfaced with the physiology based crop and climate growth models. That model was used to predict wheat yields on large areas of the U.S.

A more comprehensive wheat model was developed by Ritchie and his Group in Temple Texas (23) to predict yields of wheat from information on daily minimum , maximum temperature radiation , precipitation, the presowing soil moisture, the crop phenological calender, fertilizer N applied and the

main soil properties. Ritche emphasized the need to develop models of the water balance which depend on the input of weather records easy to obtain.

METHODS OF STUDY :

- Selection of the pilot area :

A pilot area with different soil families and ecological conditions was chosen , that extending between the coastal plain of Syria near Tartous (with average annual precipitation of 900 mm) and the Syrian steppe near Palmyra (average annual precipitation of 150 mm) . That would make a pilot area of 200 Kms long and 100 to 150 km wide . See fig (1).

- Selection of soil sites :

Experimental fields were selected in different parts of the pilot area representing different soil association according to parent materials, climatic zones, topography and profile development.

Additional information were recorded for each site such as : stoniness, slope, texture, structure, colour and soil samples were taken for laboratory analysis, with disturbed soil cores for bulk density determination. The area of the project could be classified into three groups according to climatic conditions and soil associations :

- The coastal plain and littoral plain, when soil associations are mainly typic and vertic Xerochrepts moderately fine, Hyperthermic and Chromoxererts fine Hyperthermic.

- The western mountain range where soil associations are mainly lithic Xerocrepts and typic Xerocrepts.

- The flat plateau of Homs where soil associations are mainly typic Xerocrepts Calcic Xerollic Xerocrepts and petrocalcic Xerocrepts.

- Climatic conditions of the pilot area :

The Mediterranean climate dominates in general the various parts of the pilot area chosen for the study. It is a wet and cool winter with a dry and hot summer. Precipitation ranged between 900 and 150 mm. See fig(2). The pilot area has mainly a Xeric soil moisture region. Two important characteristics could be pointed :

1. The soil depth : Some soils are shallow overlaying a petrocalcic horizons, where root zone is thin and vegetative growth is reduced .

2. The climatic variability : The rain distribution and frequency are very erratic .

- Experimental studies at the farmer's fields :

The number of farmers fields chosen in the pilot area amounted to 30 to 5o in each year, where several types of studies were carried out in each season :

1. Soil Profile Description :

Description included horizons thickness, texture, structure, plasticity, consistency, colour, stone and root distribution lime and iron concretions and presence of hardpans impeding root penetration .

Soil surface slope was measured by an abniy level and stone surface coverage percent was estimated according to U.S. Soil Survey Manual.

2. Soil Laboratory Analysis :

On soil samples taken from the plow layer complete physical and chemical determinations were carried out . That would include : The particle size distribution (Boyoucos Method) , total $CaCo_3$ (Calcimeter method), active $CaCo_3$ (Drouineau Method) ; organic matter and total mineral N, the cation exchange capacity and exchangeable K, the electrical conductivity of

the saturation extract and pH of soil paste ; and finally the available P (Olsen Method)

On soil samples taken from various horizons, it was determined the particle size distribution , $CaCo_3$, pH , field capacity and the permenant wilting point.

3. Productivity of wheat and barley :

Five square meters, chosen at random in each farmer's field, were harvested at maturity for the determination of :

- Total weight of grain, straw, average height of plants at harvest, weight of 1000 grains.
- Total weight of weeds (green + dry) in the harvested area and its percentage weight as compared to total biomass .
- Percentage number of kernels affected by covered smut
- Degree of leaf infection by rust (range from 0 to 5)

4. Meteorological data :

From the network of nearest available meteorological stations in the pilot area, to the sites chosen. The daily precipitation which is the only common measurement to all stations was recorded and considered, in the regression analysis .

5. Other measurements at the farmer's fields :

It was recorded for each site :

- Crop rotation and especailly the previous crop to wheat or barley.
- Type and amounts of fertilizers used
- Varieties used by ' e farmer
- Seed bed preparation and method of sowing .

6. Fertilizer Experiments :

During the first year of study , it was found that the amount of fertilizers used, in the pilot area , were very limited in spite of large potential response of wheat and barley to N and P fertilizers.

Starting from the second year of the project (1980-81), NP experiments in farmer's fields were carried out on wheat and barley.

The experimental design included five treatments.

O Control

N_1 , N_2 , N_1P_1 , and N_2P_2 where N_1 and N_2 are equivalent respectively to 150 and 300 kgs of NH_4NO_3 per hectar (33% N) for sites with less than 400 mm of average yearly precipitation ; and 25o and 500 kgs per ha for sites with more than 400 mm.

P_1 and P_2 are equivalent to 75 and 150 kgs of treble superphosphate (48% P_2O_5) per hectar for either arid or humid sites.

Phosphates were added completely before sowing. However, N fertilizers were split in two applications for humid sites, half before sowing and the second half at tillering stage. For the dry sites, N fertilizers were added in one application before sowing .

All field operations were carried out by the farmers except the plot harvesting and fertilizer applications.

7. Computer Analysis :

. A stepwise multiple regression program belonging to the Computer Center of Purdue University was used to analysis data and relate yields of wheat and grain or straw to various soil, precipitation and some management variables .

The output of the computer program includes at each step :

1. Correlation Coefficient R
2. Standard error of estimate
3. Analysis of variance table
4. For variables in the equation :

   a) Regression coefficient
   b) Standard error
   c) F and degree of significance
   d) Contribution of each variable to the variance

5. For variables not into the equation :

   a) Tolerance
   b) Partial correlation coefficient
   c) F to enter

Main Results And Conclusions

Contribution of Precipitation to Yield Variation of Wheat :

Soil water was found by many workers as the main variable affecting yield of crops ; and fluctuations in yields were attributed mostly to changes in available soil moisture in successive phenological stages of plant growth. Precipitation is the main source for soil moisture replenishment under the dry farming agriculture ; and because of practical difficulties envolved with field measurements of available soil moisture in widely distributed large number of sites ; it was decided to relate first yields of crops to precipitation amount and distribution (19,25) .

In the pilot area, grain and straw yields were correlated with precipitation summation starting with the early precipitation (SON = Sept. + October + November) then precipitation in the four months September to December (SD) and so on . Two additional correlation coefficients were computed between yields and winter precipitation (DJ = December + January) and or precipitation in December through February .

The main results obtained would show the following remarks : (see table 1) .

1. The correlation coefficient between total yearly precipitation and grain yields of wheat could be satisfactory in certain years, but very misleading for others. (Notice the poor value of R for 1986 season). Better value of R were found between wheat straw yields and precipitation.

2. Total precipitation fallen up to end of January gave the highest value of R with grain wheat yield .

3. Improved varieties of wheat gave a higher correlation coefficient with precipitation than local varieties . (see table 2) .

4. Correlation coefficient between grain wheat yields and total precipitation in three consecutive years combined , for the whole pilot area, was found poor (R = + 0.28) . (see fig 3) .

5. Correlation coefficient between grain wheat yields and total precipitation, for area below 400 mm, and total precipitation was found relatively good with R = + 0.64 . (see fig 4) .

6. Correlation coefficient between grain wheat yields and winter precipitation (DJ) for sites below 4oo mm was found even better (R = + 0.72) (see fig 5)

As a result, the use of total precipitation in the growing season or better the total precipitation in December and January become possible for prediction of wheat grain yields for area where total precipitation is below 400 mm. But for area above 400mm the relationship between precipitation and yields become poor. Notice the poor water use efficiency by wheat in the high rainfall area . (see fig. 6)

Consequently under the best conditions, precipitation cannot explain more than fifty percent (R2 = 0.50) of grain yield variation ; and several soil and management factors should contribute significantly to grain wheat yield variation in addition to precipitation.

Contribution of soil and fertilization and some episodic events to grain wheat yield variation :

Several soil factors will affect the efficiency of rain water and hence the amount of water that could be stored in the soil profile. Soil depth and texture will determine the maximum possible depth of water that could be stored . In dry years, the total soil depth might not be used for water storage ; and consequently both deep and shallow soils could have the same amount of stored water. But in wet years water will percolate to deeper horizons of soils and be stored and used in the season to extend the potential growing season and the final stages of growth and as a result an increase in yields ; while in shallow soils, a substantial part of the precipitation water might be lost by deep percolation or surface runoff , without contributing to water requirement of crops (12) .

Other soil properties would affect the efficiency of rain water and its storage in the soil profiles such as the surface slope, which have a strong impact on possible loss of water by surface run off and the infiltration rate of water in soil which is related mostly to soil structure of various horizons .

Cereals grown in deep soils under the Mediterranean climate, with large storage capacity should be then less exposed to high water stress at the end of the growing season as plants grown in shallow soils. Thus soil depth, texture, surface slope, water infiltration rate and soil water relationships would have an impact on yields and will contribute significantly to wheat and barley yields variation (2).

Other soil properties were found to affect yields of cereal crops grown under the rianfed agriculture such as the poor level of available nutrients, needed by crops , either indirectly by affecting the water use efficiency or directly to meet the nutrient requirement of crops. Nitrogen stands as the most limiting nutrient factor for plant growth under the Mediterranean climate especially in area where average annual rainfall exceeding 250 mm . Water might be the most limiting factor in the dry years ; but nitrogen rather than water will be the factor that affects yields in wet and rainy years.

Phosphorus stands after nitrogen as the second next important nutrient limiting plant growth in the Syrian soils. Under the field conditions and in long term experiments at Izraa Experimental Station it was found that response of wheat and lentil to phosphate was greater in dry years as compared to wet years (2) . Harmsen and Krentos confirmed the same results on barley and other crops (9,1) . Several interpretations were given to the beneficial effect of phosphates under arid and dry conditions . P increased the rate of development of crop resulting in maturity being advanced as for barley for one to two weeks (12) .

Thus the water use by crops is reduced by addition of phosphate in spite of the more rapid development and higher values of the green area index Other consider that P improves root development and proliferation, thus extending the soil volume for available eater and nutrients (2,9) ; and improve the

tolerance of field crops to aridity . Thus P is a major soil nutrient affecting yields or rainfed crops under arid conditions .

Other soil properties, could have a significant effect on cereal growth and yields. High free lime levels in soils may cause stunted growth as a result of P and micronutrient immobilization as well as a serious ammonia volatization losses in case of improper management (15) .

Using the stepwise multiple computer program for computation of results obtained in the 1981 and 1982 crops combined with the exclusion of the 1980 crop since fertilization weed and smut estimation had not been considered; it was found that several soil properties, and some rainfall nutrients interaction variables were correlated significantly with yields of wheat in grain and straw and height of plants at maturity . (see table 3) .

Clay content of soils correlated positively with yields of grain (R = + 0.52) and straw (R= + 0.51) while silt and sand correlated negatively Cation exchange capacity correlated similarly with yields of grain and straw with (R = +0.40 and 0.45 successively) .

Stoniness of the soil surface (STONES) was negatively correlated with yields of grain (R = -0.44) or straw (R= -0.47) . The number of plants per unit area is expected to decrease as the percent stoniness on soil surface increased, which in turn limit yields.

Soil depth was positively correlated with wheat yield of grain (R = + 0.49) or straw (R = +0.38) .

Bulk density which is an indication of soil structure, was negatively correlated with yield of wheat. High bulk density could lead to a bad aeration of soil and a poor water percolation of heavy soils.

Nitrogen fertilizer correlated significantly with wheat yields of grain or straw; but the product rainfall - N added (RAIN -N) had a more significant value of R with yields .

The interaction variable Rain x soil available phosphorus (RAIN-PS) had significant correlation coefficient with grain (R=+0.35), or with straw (R=+0.33) .

Weeds in soils stand as the most significant variable in the pilot area affecting negatively yields of grain (R = -0.57) and straw (R = -0.53) . Weed in wheat fields compete with plants for water and nutrients. Weed infestation is widespread throughout the area, and no real effort was spent by the farmers to control its damage to crop production in the rainfed area. The drop in yields of wheat grain as function of percent weed weight % as shown in fig (7) is represented by the linear regression equation for all sites considered in the pilot area :

$$GRAIN = 185.677 - 3.215\ WEED$$

where Grain is yield of grain in kg/donum .

A weed infestation of 20 percent by weight of total harvest as an example could drop yield by 30 percent . Many fields in the pilot area were more infested by weeds than 20 % .

Regression equation relating yield of wheat to soil variables and precipitation :

By use of the stepwise regression computer program, a series of regression equations were obtained in every step a variable is introduced into the equations . The coefficient of determination R^2 and the contribution of each new variable introduced into the model to yield variation are determined automatically . That type of analysis allowed a classification of variables in their effect on yield of grain or straw .

Four different types of equations were chosen as the most significant for grain yields prediction for the 1981 and 1982 crops combined; where five variables could account for 70% of wheat yield grain variation (R^2 = 0.71) .

Weeds stand as the most significant variable . See table (4). Raising the number of variables in the regression model, to eleven, the value of R^2 raised to 0.81 . However, it was found further that raising the number of variables to 40, did improve the wheat yield prediction to 85 and 86 percent of yield variation for grain and straw respectively .

From tables (4 and 5) one could notice several important results that could be used in any further new technology to improve wheat yields.

First weeds infestation is the most important factor that could be controlled to improve wheat grain or straw yields. The use of herbicides and or any other cultural method to control weeds is a technology that would improve yields of wheat significantly .

Second Stoniness density at the soil surface is an important factor affecting negatively yields . Any practical method and technique that reduce stoniness, should improve wheat yield .

Third Clay soil or clay loam soils are the most suited for wheat. Perhaps that will be due to their high water holding capacity and or to its high cation exchange capacity and exchangeable nutrient cations.

Fourth The product of soil phosphorus and rainfall was found as a major factor affecting wheat yield of grain, and consequently improving the level of available P in rainfed soils is a very desirable technology .

Fifth The product of level of N added to the soils and rainfall is found as an important factor affecting wheat yield of straw . Consequently further studies on N level needed and rainfall is highly needed to improve straw yield of wheat, as a potential source of animal feed.

Sixth High bulk density was found an important factor affecting negatively wheat yields . Consequently any technology that improves soil aggregation in the rainfed area and lower by then, bulk density should lead to an improvement of wheat yield .

As a result, when grain wheat regression models obtained from 1981+ 1982 crops included in Table (15) were used to predict yields for the 1983 crop. It was found that grain yield prediction was fairly good. The coefficient of correlation between observed and predicted yields was fairly good with (R = + 0.94) see (fig 8). Discrepancies between predicted and observed yields appeared only in fields affected by water logging conditions or where some exceptional high density of ants colony, led to an early drop of wheat grain from kernels .

CONCLUSIONS AND RECOMMENDATIONS

Transfer of agricultural technology to improve rainfed agriculture in the Arab World is still one of the most promising ways to control food shortage and demands . Average wheat yields per unit area in the last thirty years was found more or less stagnant . The present work could have the merit to suggest a simple methodology to determine the main factors that could be controlled or improved to increase productivity or rainfed soils. Variables and factors that should be controlled to improve yields, could be different for any soil - climate - management associations. Field work is needed for every different agro-ecological zone , to establish regression models that could be used to predict yield variation with any change in agricultural technology.

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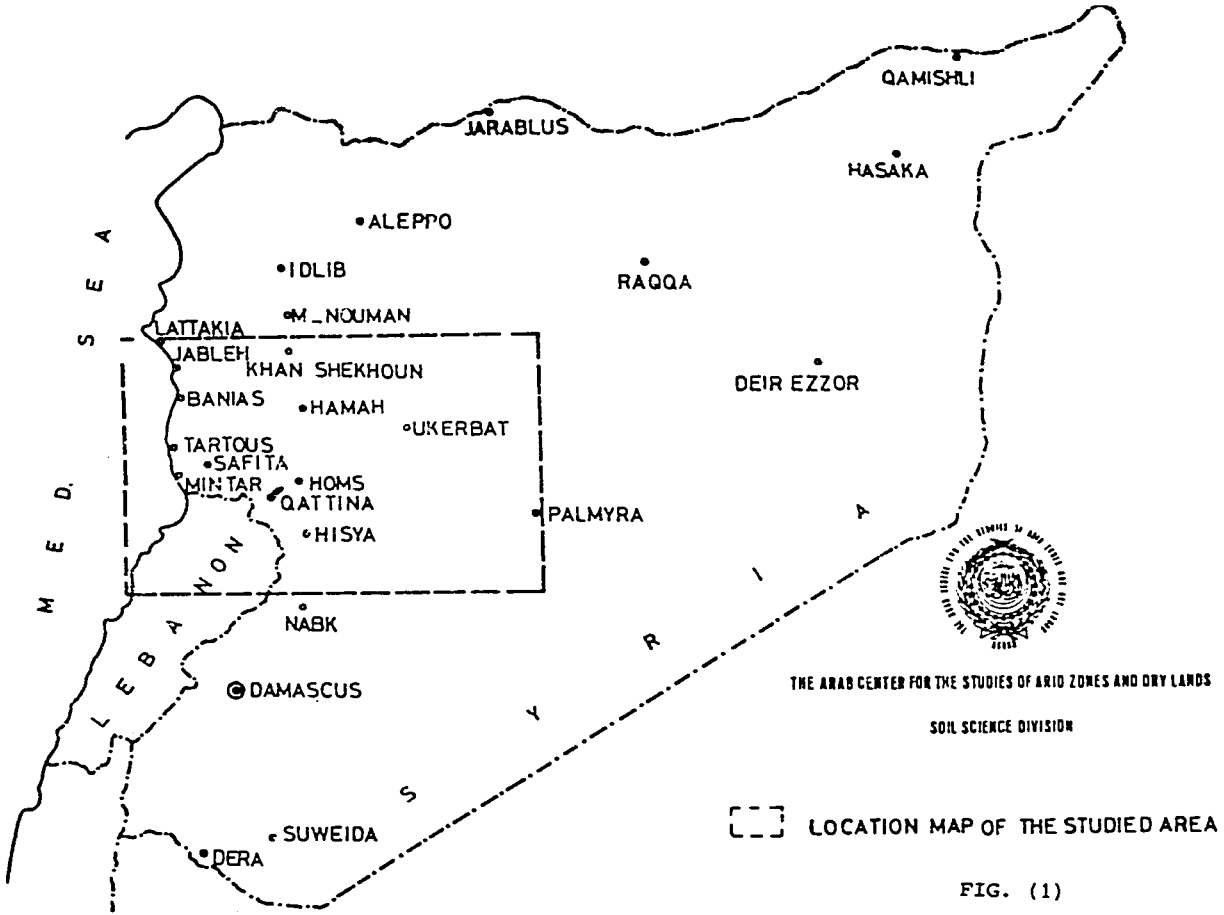
QAMISHLI
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HISYA
NABK
DAMASCUS
SUWEIDA
DERA
MED. SEA
LEBANON
SYRIA
THE ARAB CENTER FOR THE STUDIES OF ARID ZONES AND DRY LANDS
SOIL SCIENCE DIVISION
LOCATION MAP OF THE STUDIED AREA

FIG. (1)

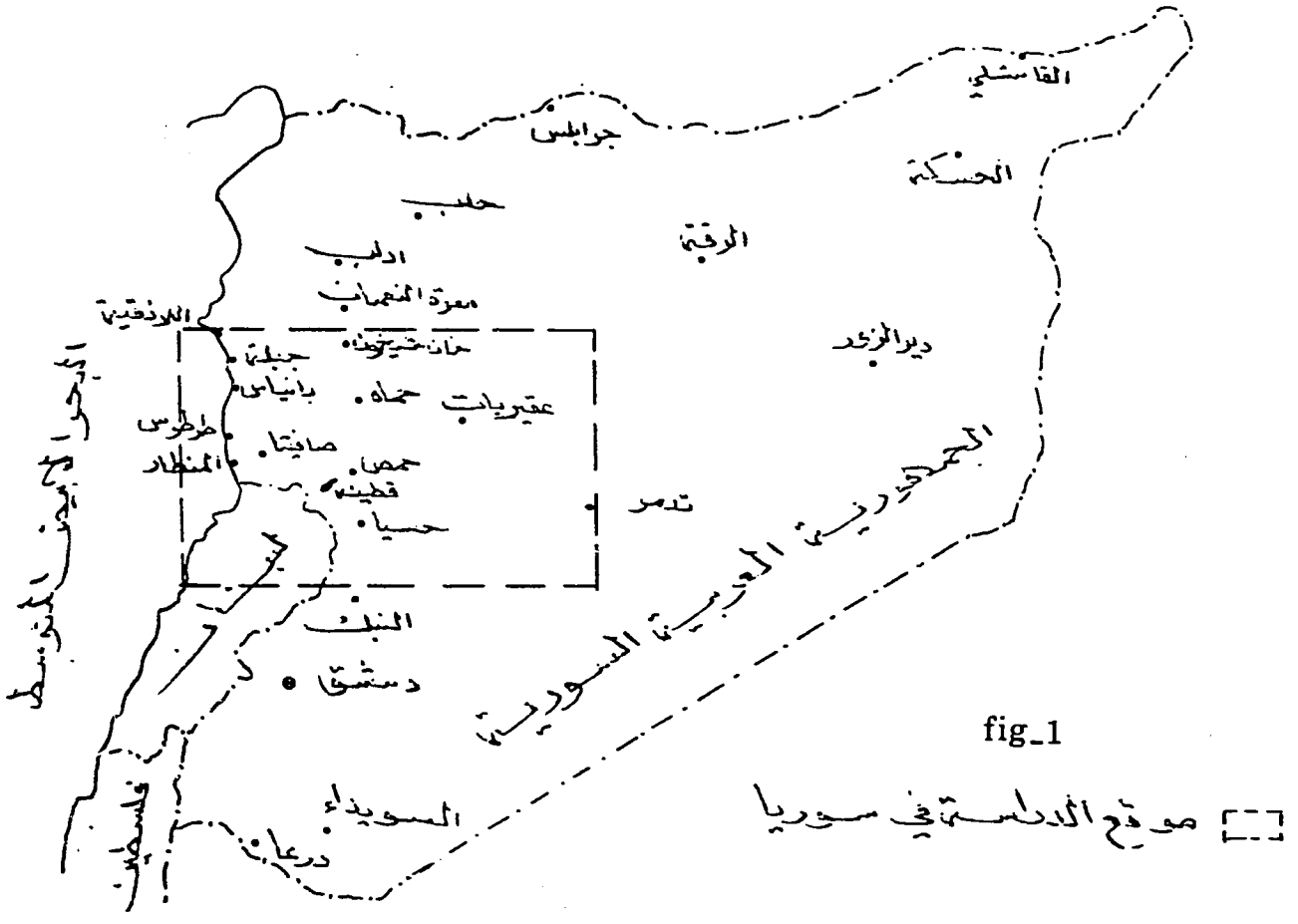


fig_1

موقع الدراسة في سوريا

النظام الرطوبي والحراري في أراضي سورية ولبنان

FIG. (2)

fig_2 Soil Temperature & Moisture Regimes of Syria and Lebanon

TABLE (1) : Correlation coefficient between summation of precipitation in various months of the growing season with yields of wheat in grain and straw for the years 1980, 1981 and 1982 in farmer's fields.

Rainfall in months*	Correlation coefficient (R) with					
	Grain Yield			Straw Yield		
	1980	1981	1982	1980	1981	1982
SON	0.07	.44	.76	.47	.46	.70
S to D	0.09	.58	.76	.46	.56	.62
S to J	0.08	.58	.76	.48	.76	.69
S to F	0.08	.65	.67	.48	.55	.62
S to MAR	0.09	.62	.69	.47	.62	.63
S to APR	0.12	.59	.70	.47	.65	.63
S to MAY	0.09	.61	.70	.47	.61	.64
D + J	0.10	.59	.71	.49	.69	.68
D to F	0.09	.68	.58	.48	.67	.53
D to MAR	0.04	.66	.63	.47	.65	.58
D	0.03	.29	.75	.31	.29	.67

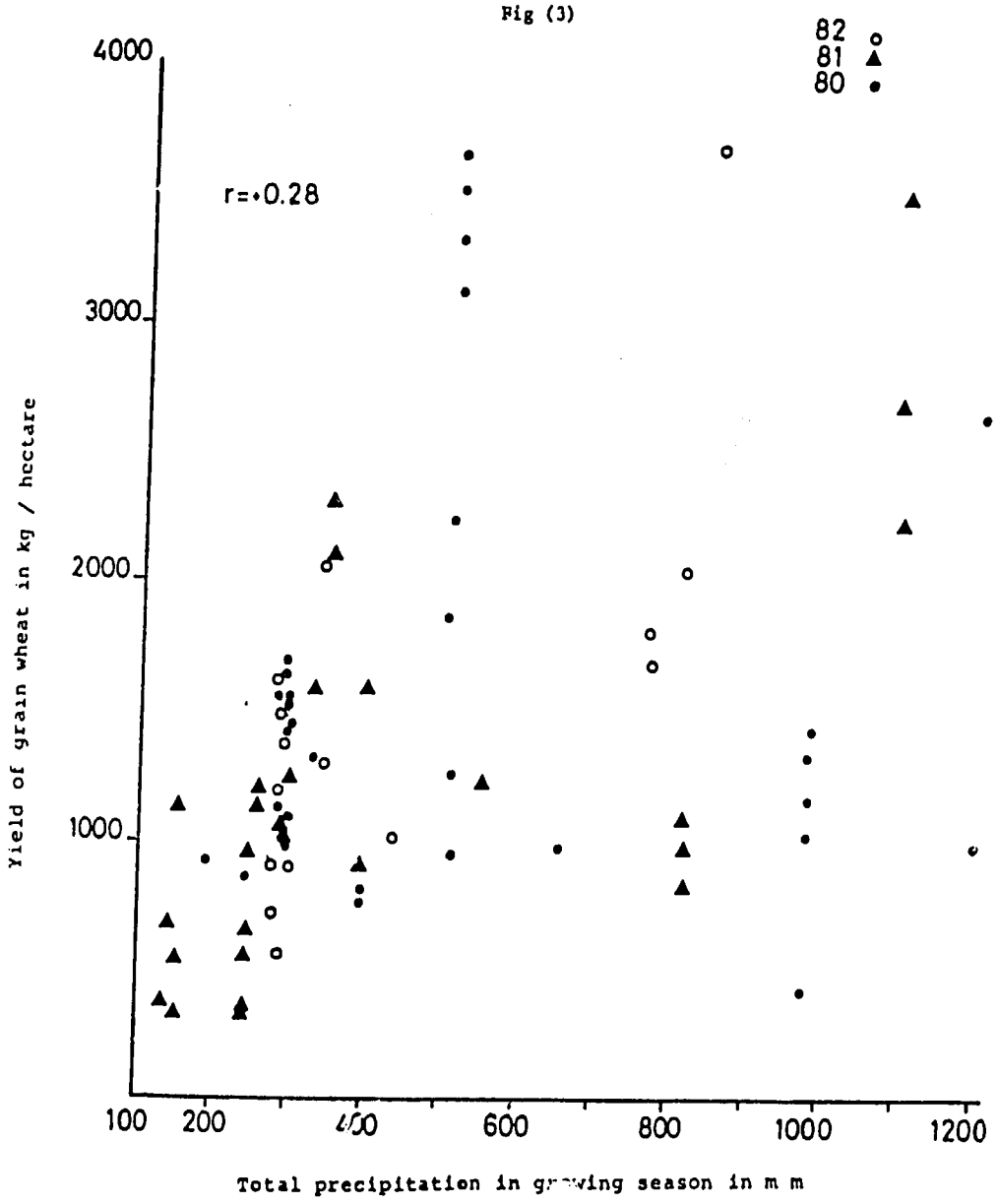
* Months were nominated by their letters.

TABLE (2) : Simple correlation coefficients between Grain yields of local and improved varieties of wheat and total precipitation in the growing season for the year 1980, 1981 and 1982 .

Varieties	Correlation Coefficients (r)		
	1980	1981	1982
All varieties together	- 0.07	+ 0.61	+ 0.70
Local varieties *	- 0.18	+ 0.62	+ 0.74
Improved varieties	+ 0.29	+ 0.82	+ 0.89

* Local Varieties : Hourani, Bayadi, Baladi, Hamari,
improved Varieties: Florence Aurore, Mexipak

Fig (3)


82
81
80
r=+0.28
4000
3000
2000
1000
Yield of grain wheat in kg / hectare
100
200
400
600
800
1000
1200
Total precipitation in growing season in m m

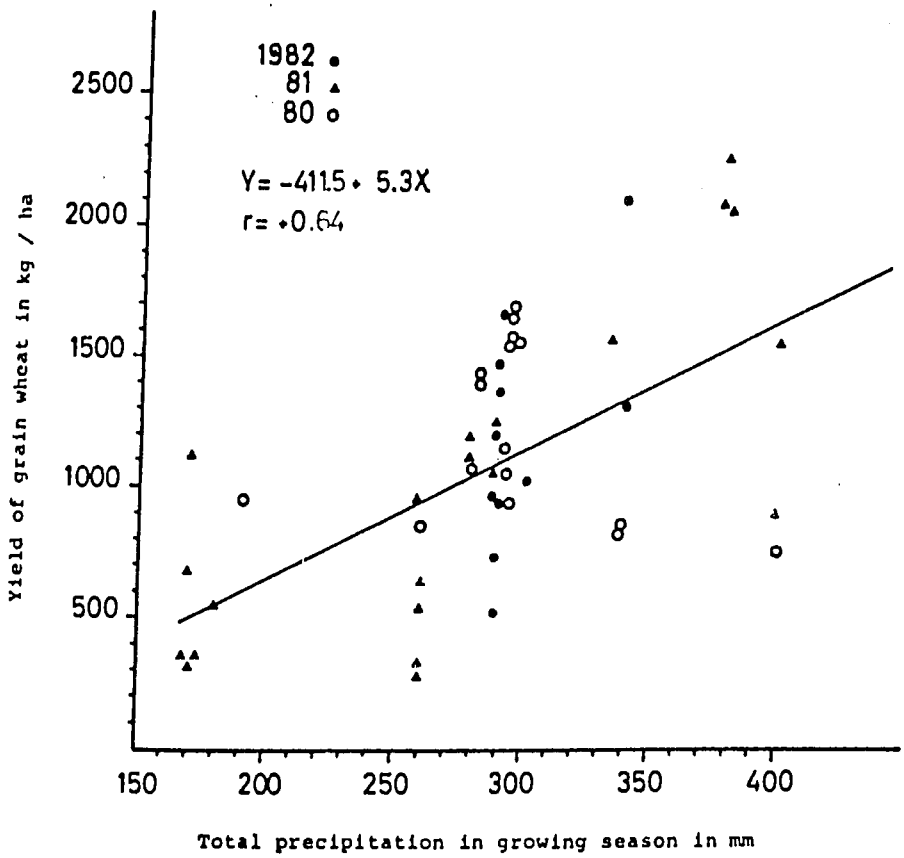


Fig (4) Yield of grain wheat and total precipitation in growing season in area below 400 mm as average annual precipitation .

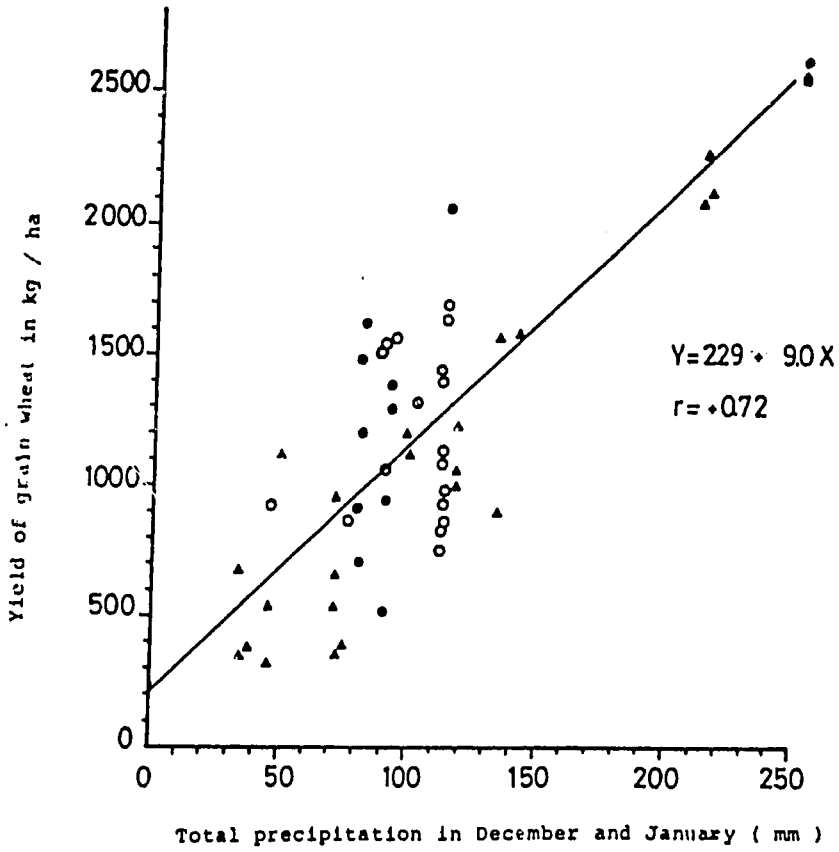


Fig (5) Yield of grain wheat and total precipitation in December and January

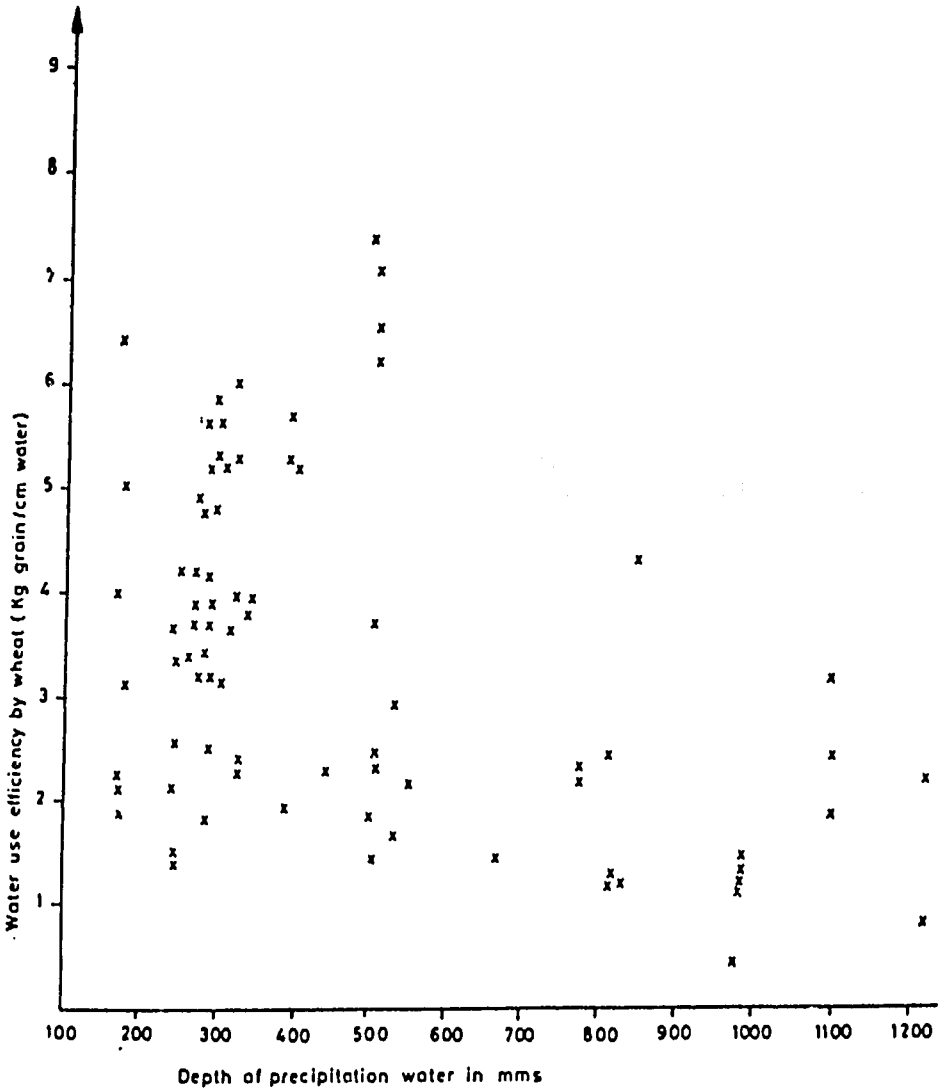


Fig.(6) - Water use efficiency by wheat as function of total precipitation in the growing season for the years 19[illegible], 1981 and 1982 .

TABLE (3) : The multiple correlation (R) between yield components of wheat varieties combined with some soil tests and environmental variables for the year 1981 and 1982 combined.

Variables	Description	WHEAT		
		Grain	Straw	Height
SD	Soil depth	.49**	.38**	.34**
STONE S	Stoniness % of surface	.44**	.47*	.45**
CEC	Cation exchange cap.	.40**	.45**	.27*
SILT	Silt	-.27**	-.26**	-.00
SAND %	Sand % in soil	-.39**	-.37**	-.25*
CLAY	Clay %	.52**	.51**	.19*
BD	Bulk density	-.32**	-.38**	-.09
NADD	Fertilizer N added	.24**	.27**	.27**
WEED	Weed % by wt	-.57**	-.53**	-.50**
RAIN-N	Rainfall-N interaction	.31**	.34**	.35**
RAIN-P	Rainfall-P added =	.29**	.30**	.27**
RAIN-PS	Rainfall-Soil P =	.35**	.33**	.36**
CALA	Active $CaCo_3$	.27**	.06	.07
ALT	Altitude	-.51**	-.45**	-.49**
RUST	Smut disease %	-.13**	-.15**	.009

* , ** Significant at .05 and .01 levels respectively

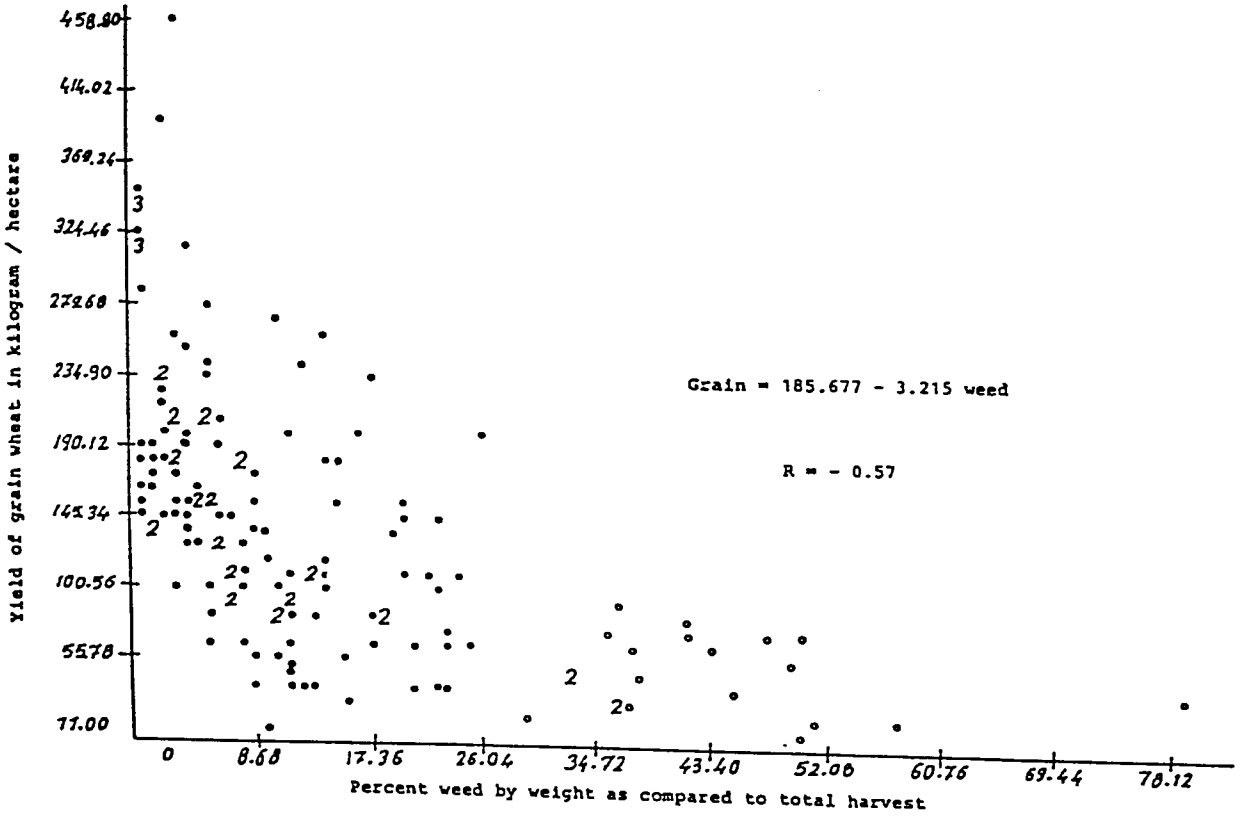


Fig (7) Yield of grain wheat as related to weed % by weight.

TABLE (4) Regression models for grain yields of wheat with the respective coefficient of determination R^2 for the 1981 and 1982 crops combined using the stepwise multiple regression .

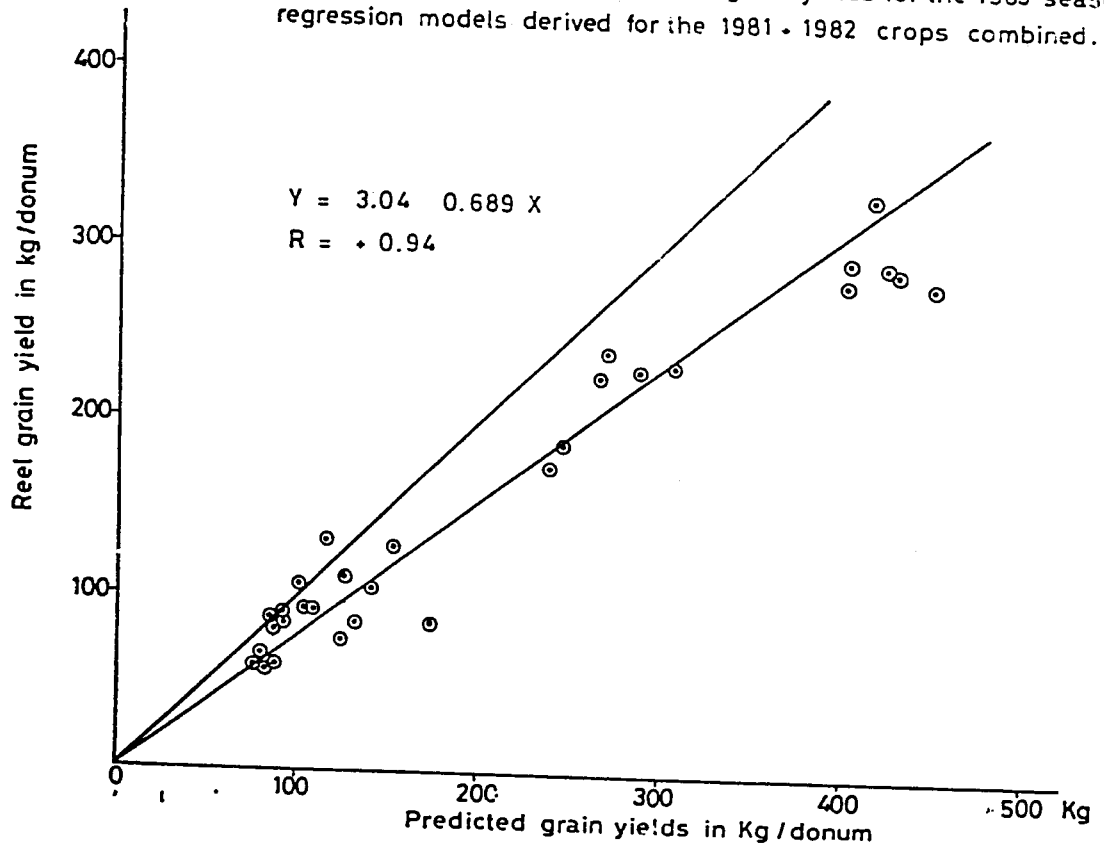
Mean Grain Yield in kg/1000 M2		Regression Equations	R	R^2
Y_1	=	3.247 - 1.648 WEED + 3.758 CLAY - 1.512 STONES +3.982 CALA + .243 RAIN PS	0.84	.70***
Y_2	=	-14.073 - 1.604 WEED + 3.721 CLAY - 1.49 STONES + 4.223 CALA + .215 RAIN PS + 2.843 NADD	0.85	.73***
Y_3	=	-107.820 - 1.449 WEED + 4.042 CLAY - 1.805 STONES + 4.498CALA + .255 RAIN PS + 3.056 ADD + 58.976 EC + 1.277 HORA	0.87	0.75***
Y_4	=	-8.728 -1.075 WEED + 4.430 CLAY - 1.322 STONES + 3.935 CALA +0.307 RAIN PS + 2.318 NADD + 76.24 EC + 2.31 OHORA - 127.679BD - 1.512 SMUT + 0.409 P_2 ADD	0.90	0.81***

*** Significant at 0.001 level

TABLE (5) : Regression models for straw yields of wheat with the respective coefficients of determination for the 1981 and 1982 crops combined using the stepwise multiple regression .

Mean Straw Yield kg/1000 M^2		Regression Equations	R^2
Y_1	=	105.082 - 2.850 WEED + 6.367 CLAY - 3.958 STONES + 12.000 SLOPE + 0.241 RAIN N	0.65**
Y_2	=	-1o4.502 - 2.680 WEED + 8.294 CLAY - 5.455 STONES + 10.258 SLOPE + .245 RAIN N + 129.794 EC + 8.711 PHOS	0.71**
Y_3	=	155.417 - 2.130 WEED + 8.949 CLAY - 5.531 STONES + 4.144 SLOPE + 0.192 RAIN N + 144.251 EC + 1o.111 PHOS - 224.205 BD + 1.138 P^2 ADD	
Y_4	=	215.554 - 1.440 WEED - 6.648 CLAY - 5.329 STONES + 6.930 SLOPE - 0.156 RAIN N - 117.463 EC - 13.219 PHOS - 270,677 BD - 1.246 P^2 ADD - 1.368 SD - 1.831 CALT .	0.79**

Fig.(8) Relation between predicted wheat grain yields for the 1983 season from regression models derived for the 1981 + 1982 crops combined.



FIELD EXCURSIONS IN JORDAN

BY : WILLIAM M. JOHNSON

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In the Book of Chronicles of Soil Taxonomy it will be written that on May 14th, 1984 (the year 1404 in the Arab calendar) a group of 37 scientists assembled in Amman to study soil classification, especially in its application to some soils of Jordan. In this forum were 19 trainees and 18 resource people, a ratio of about 1:1, and not even the State University of Ghent can boast of such intensive instruction!.

During the six days of field excursions we travelled about 1,600 kilometers . We traversed the full length of Jordan, about 400 kilometers from the Yarmouk Valley south to the Red Sea at Aqaba and from Jordan Valley eastwards to Azraq . We became acquainted, if only briefly, with five of Jordan's physiographic provinces :

The Rift Province (Dead Sea, Jordan Valley)
Mountain Ridge and Northern Highlands East of the Rift .
Southern Desert
Central Plateau
Azraq-Wadi Sirhan Depression

We were previliged to examine and discuss 12 pedons in remarkably well prepared pedological excavations (soil pits). we walked several kilometers in hot sun to view the marvels of Nabatean architecture at Petra. In spite of all the vigorous exercise, the strong sun and the hazards of some very deep pits, we all survived without injury or illness . In fact, it seems that the greatest hazards encountered was the risk of over-eating because of the many delicious , varied and remarkably generous luncheons and dinners we were served.

All participants received the official list of study pedons and their classification in Soil Taxonomy . These soils represent five soil orders and are an excellent expression of the range in soil conditions in Jordan. The following classification chart shows the distribution of study pedons in the various orders and gives few notes concerning the classification of each .

Soil Classification Chart - Jordan

1. ENTISOLS

J9 (pit not seen). Typic Torrifluvent, fine-silty, mixed (calcareous), thermic .
Stratified ; irregular decrease of organic carbon; ochric epipedon but no other diagnostic horizons.

J11 (19 May) . Pasture just outside Azraq. Aquic Torriorthent, clayey skeletal, mixed (calcareous), thermic . Incorrect colors in pedon description caused some confusion. Ochric epipedon. Saline in upper horizons but not a salic horizon. Lots of exchangeable sodium and soluble sodium chloride but there is no way to reflect this sodicity in Soil Taxonomy.

2. INCEPTISOLS

J4 (21 May). Deir Allah Experiment Station, Jordan Valley . Fluventic Ustochrept, fine, mixed, hyperthermic . Irregular decrease with depth of organic carbon. Ochric epipedon and cambic horizon (based on soft powdery lime concentration below). Some vertic properties but not enough for an intergrade.

3. ARIDISOLS

J1 (17 May) In a newly planted apple orchard south of Ma'an. Typic Calciorthids, loamy-skeletal, carbonatic, thermic. Aridic moisture regime. Ochric epipedon, possibly a cambic horizon ; calcic (hypercalcic) horizon.

J2 (17 May) Near village of Mohammedieh, north of Ma'an. Typic Calciorthids, clayey-skeletal. carbonatic, thermic. Irregular distribution of organic carbon; 20 - 68% exchangeable Na; stratified material; may have a natric horizon but more data are needed to be sure; ochric epipedon ; calcic horizon; salic horizon . More important to recognize high sodium absorption ratio than salic horizon.

J3 (22 May) Edge of eggplant field in southern part of Jordan valley.
Fluventic Ustollic Camborthids, fine-silty, carbonatic, hyperthermic . Ochric and cambic horizons. Presents complicated calssifications problem .

J8 (19 May) In abroad, shallow depression, Wadi Schaumeri, near Azraq.
Typic Gypsiorthids; sandy, gypsic, thermic. Irregular decrease of organic carbon with depth. High sodium below 1 meter depth. Ochric, gypsic and salic horizons. Petrogypsic in places.

J10 (19 May) Low, wet meadow at town of Azraq .
Aquic Natrargid; very fine, carbonatic , thermic. Ochric, natric and calcic horizons. Some vertic properties .
A vertic subgroup, as in Haplargids , would be useful here.

J12 (20 May) Alongside highway to Baghdad, 14 Km. north of Azraq. Typic Natrargid; fine-loamy , mixed, thermic . Ochric, natric, calcic and gypsic horizons. Columnar structure is not strong and the natric horizon is not strongly expressed .

4. MOLLISOLS

J13 (not seen) Typic Argixeroll, clayey- skeletal, montmorillonitic, thermic

5. VERTISOLS

J5 (22 May) Experiment Station 32 Km. south of Amman, in fallow field on a gentle slope.

Entic Chromoxerert; fine, montmorillonitic, thermic. Ochric epipedon; prominent vertic properties and some scientists dislike the entic intergrade ; possibly has cracic horizon but pedon not sampled deep enough to be sure; possibly has oxidic mineralogy ?.

J6 (20 May) Fallow field in Ramtha Agricultural Experiment Station. Entic Chromoxerert; fine, montmorillonitic, thermic . Ochric epipedon ; some vertic properties, possibly has an aegillic horizon ? Has some ustollic properties

J7 (20 May) Edge of Chickpea field on Maraw Experiment Station . Typic Chromoxerert ; very fine, montmorillonitic thermic. Ochric epipedon ; distinct vertic properties some clayskins may be present .

J14 (21 May) Fallow field near North Shema, Jordan Valley. Entic Chromustert; fine, carbonatic, hyperthermic. Ochric epipedon ; vertic properties clearly seen; some participants expressed dislike of " entic " intergrade .

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Note : It appears possible that Alfisols may also exist in the more humid areas of Jordan , but we saw no examples .

APPENDIXES I. II. III.

APPENDIX I

VIII International Forum
on
Soil Taxonomy and Agrotechnology Transfer

Jordan, May 14-25, 1984

PROGRAMME

MAY

Sunday 13,	Participants Arrival
Monday 14,	Opening Ceremony
10.00	Chairman: Mr. Z. Ghosheh, ACSAD representative in Jordan
	- Dr. H. Eswaran, Project Leader, USAID
	- Dr. M. EL-Khash, Director General, ACSAD
	- H.E.M. S. Al-Louzy, Under-Secretary, Ministry of Agriculture, Jordan
11.00	Break
	Technical Session I
	Chairman: Dr. A. Osman
11.30	Purpose of the Forum - A. Osman
	(Introduction of staff and participants)
12.00	Principles and logic of Soil Taxonomy, H. Eswaran
12.45	The Need for a worldwide system of soil classification, F. Moormann
13.30	Lunch
	Technical Session II
	Chairman, A. Taimeh
14.30	Soil Moisture and temperature regimes, R. Tavernier
15.30	Diagnostic surface horizons, W. Johnson
16.30	Break
17.00	Diagnostic subsurface horizons, cambic, argillic, spodic, oxic - F. Moormann
18.00	Discussion
18.30	Adjourn

Tuesday 15,	Technical Session III
	Chairman: H. Haj Abdallah
08.00	Diagnostic subsurface horizons, calcic, petrocalcic, gypsic, petrogypsic, salic - A. Osman/ M. Ilaiwi
09.00	Diagnostic properties - F. Moormann
10.00	Break
10.30	Nomenclature and keys to Soil Taxonomy - R. Tavernier
11.30	Use of Soil Taxonomy in soil survey programs - W. Johnson
12.30	Lunch
	Technical Session IV
	Chairman: M. Ilaiwi
14.00	Alfisols- F. Moormann
15.00	Aridisols- A. Osman
16.00	Break
16.30	Entisols - W. Johnson
17.30	Break
18.00	Soil Taxonomy - a technical language of Soil Science (Movie), Introduced by H. Eswaran
	ACSAD Activities (Movie), introduced by Dr. A. Osman
Wednesday 16,	Technical Session V
	Chairman: A. Mogbil
08.00	Inceptisols - M. Ilaiwi
09.00	Mollisols - R. Tavernier
10.00	Break
10.30	Geology and Geomorphology of Jordan - B. Sunaa'
11.30	Ultisols - F. Moormann
12.30	Vertisols - W. Johnson
13.30	Lunch
	Technical Session VI
	Chairman: W. Johnson
15.00	Soil Families - H. Eswaran
16.00	Climate of Jordan - Y. El-Kawasma
16.30	Break
17.00	Landuse in Jordan - B. Al-Qudah

17.30	Soil of Jordan - A. Rehani
18.00	Soil Profile Description - H. Fadl
18.30	Adjourn
Thursday 17,	Field Tour (340 Km)
07.00	Leave Amman
10.00	Pedon J2 (220 Km), Discussion Leader - H. Eswaran
11.30	Basquet Lunch
14.00	Pedon J1 - Discussion Leader - F. Moormann
16.00	To Aqaba
	Night at Aqaba
Friday 18,	
08.00	Tour of Aqaba
11.00	Leave Aqaba to Petra (180 Km)
13.30	Lunch at Petra
15.00	Leave Petra to Amman (260 Km)
	Night in Amman
Saturday 19,	
07.30	Leave Amman for Azraq (110 Km)
10.00	Pedon J8, Discussion Leader - M. Ilaiwi
11.30	Pedon J10, Discussion Leader - S. Nooman
13.00	Lunch at Azraq (check-in hotel)
15.00	Pedon J11, Discussion Leader, N. Khatib
	Night in Azraq
Sunday 20,	Azraq to Irbid (150 Km)
08.00	Pedon J12, Discussion Leader, I. Dhaiaa'
10.00	Pedon J6 (120 Km), Discussion Leader, H. Fadl
11.30	To Irbid
13.00	Lunch at Irbid
14.30	Pedon J7, Discussion Leader, B. Al-Qudah
	Night at Irbid
Monday 21,	
08.00	Irbid to Deiralla (80 Km)
10.30	Pedon J14 (30 Km), Discussion Leader - A. Moqbil
11.30	To Pedon J4 (Deiralla), Discussion Leader, A. Osman
	Basquet Lunch at Deiralla
12.30	Return to Amman (70 Km).
	Night at Amman

Tuesday 22,

08.00	Leave Amman (70 Km)
	to Pedon J3, Discussion Leader, R. Tavernier
10.30	Leave to Dead Sea
12.00	Lunch
14.00	Swiming in Dead Sea
15.00	Leave to Pedon J5, Discussion Leader, W. Johnson
16.00	Return to Amman (100 Km)
	Night at Amman

Wednesday 23,

	Technical Session VIII
	Chairman: N. El-Khatib
08.00	IBSNAT - An International Programme
09.00	Agrotechnology Transfer in the Arab countries under rainfed agriculture - A, Matar .
10.00	Break
10.30	A synopsis of the Benchmark Soils Project
11.30	Wheat and Barley Management in Jordan - Z.Ghoshch
12.15	Spray of Urea on Olive trees - I.Saket
13.00	Soil Conservation of Jordan - N. Haddadeen
14.00	Lunch (Invitation by H.E.M. The Minister of Agriculture)
	Technical Session VIII
	Chairman: F. Beinroth
16.30	Soil Temprature Regime and relationship between air and soil temperature in Jordan - A. Taimeh
17.15	Replenishment and depletion of soil moisture in the northern rainfed areas of Jordan - A.M. Battikhi
18.00	Adjourn

Thursday 24,

	Technical Session IX
	Chairman: R. Tavernier
08.00	Soil Map of Arab Countries (ACSAD) - M. Ilaiwi
08.30	Sudan: H. Fadl
09.00	Iraq: H.M. Al-Naimi
09.30	Panel Discussion, National Soil Survey Program in Jordan
10.00	Break

Technical Session X : Forum Reports

Chairman: H. Eswaran

10.30	Field Tour - W. Johnson
11.00	Soil Taxonomy Lectures - B. Al-Qudah
11.30	Management Lectures - B. Babikr
12.00	Participants comments
12.30	Recommendations
13.00	Conclusion and Distribution of Certificates

RECOMMENDATIONS

DRAFTING COMMITTEE :

1. Dr. Hari Eswaran (SMSS)
2. Mr. Jihad M. Abu Mushrif (Jordan)
3. Mr. Abdallah S. Al-Dukail (S. Yemen)
4. Dr. Hassan H. Abdallah (Sudan)
5. Dr. Mohamed Ilaiwi (ACSAD)
6. Mr. Bakr H. A. Qudah (Jordan)

The drafting committee met on Wednesday May 23rd from 6.00 to 7.15 p.m. and proposed the following commendation and recommendations.

Commendation

The participants of the VIII International Forum on Soil Taxonomy and Agrotechnology Transfer wish to express their appreciation to the Government of the Hashemite Kingdom of Jordan and in particular to the Ministry of Agriculture for hosting the Forum and providing the logistical support which ensured a successful conclusion.

The participants also wish to thank the co-sponsors: The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), the Soil Management Support Services (SMSS) and the Agency for International Development (AID) - for their financial and organizational support of the Forum.

The Forum was attended by participants from ten countries (Jordan, Syria, Saudi Arabia, Kuwait, Yemen Arab Republic, Yemen Democratic Republic, Iraq, Sudan, Somalia and Qatar) and we wish to express our gratitude to the respective governments for permitting us to attend the Forum.

The success of the Forum was largely due to the quality of the Resource Personnel and we are deeply indebted to them for all their inputs into the Forum

Proposed by : Dr. H. H. Abdullah
Seconded by: S. Nooman

Recommendations

1. Realising the need for international exchange of scientific information and noting the need for more qualified and trained personnel in the Arab Countries, the participants strongly urge SMSS and ACSAD to organize follow-up Forums in the region. The participants strongly recommend that two Forums be planned for the near future:

   (a) A forum on Soil Taxonomy and Techniques on Soil Analysis and Evaluation to be held in early 1985.

   (b) A Forum on "Soil Survey Methodology and Interpretation of Soil Surveys" to be held in late 1985 or early 1986.

Proposed by: A. Rihani
Seconded by: W. Johnson

2. The participants fully endorse ACSAD's efforts in the Soil Map of the Arab World project and appreciate the collaboration of SMSS and other organizations in this project. In order to facilitate the operational aspects of the Project and to ensure quality control, the participants recommend the translation of the following two documents into Arabic:
   (a) Key to Soil Taxonomy
   (b) The New Soil Survey Manual
   To ensure an unambiguous translation, the participants recommend that a Committee of Soil Scientists of the Arab Countries be formed by ACSAD to verify terminology and guaranty quality of the translation. It is also recommended that SMSS be invited to collaborate in this project.

Proposed by: B. Babikr
Seconded by: F. Jack

e. In view of the need for training soil scientists in the Arab Countries and to create a greater awareness for the discriminatory use of soils among national planners and users of soils, the participants recommend that ACSAD in collaboration with the International Soil Research and Information Center, (ISRIC) - Netherlands- establish a soil monolith collection at its headquarters.

ACSAD is also requested to assist countries who will be interested to establish their own national soil monolith collection.

Proposed by: H. Jamous
Seconded by: H. Fadl

4. Considering the need for an efficient national soil survey staff in all arab countries, the Forum urge all government and decision makers in the Arab Countries to establish, if not yet existing, a National Soil Survey Service at the Ministry of Agriculture and to supply this service by the necessary means to be able to carry on all soil studies and to elaborate detailed and semi detailed soil map for different development projects in the country. This Service should be able to cooperate and participate in the scientific activities of the soil specialists of the Universities and other scientific institutions and advice national and regional planners on the discriminatory use of soils.

Proposed by: B. Babikr
Seconded by: A. Al-Dukail

5. Noting that Vertisols are very extensive in the Arab Countries and that much of the agriculture of the Arab World is on these soils, the participants welcome the initiative of the International Board for Soil Resources and Management (IBSRAM) to develop a Soil Management Network on Vertisols. The participants request IBSRAM to include as many arab countries as possible in this Network as we realize the benefits of this trans-national

collaboration to improve the productivity of these soils.

Proposed by: H. Fail
Seconded by: A. Taimeh

6. Recognizing the potential of models in agricultural research and development, the participants recommend that the member countries of ACSAD actively explore the possibilities of collaborating with IBSNAT, either individually or through ACSAD.

Proposed by: A. Muqbil
Seconded by: M. Ilaiwi

APPEN:

LIST OF PARTICIPANTS

S.NO.	N A M E	COUNTRY	ADDRESS	
	LECTURES			
01	R.Tavernier	Belgium	University of Ghent	
02	W.Johnson	U.S.A.	Portland, Oregon	
03	F.Moormann	Holland	University of Utrecht	
04	H.Eswaran	U.S.A.	USAID	
05	F.Beinroth	U.S.A.	IBSNAT/U.S.A.	
06	A.Osman	Lebanon	ACSAD/Damascus	P.O.Box 2440 - Damascus
07	M.Ilaiwi	Syria	ACSAD/Damascus	" " "
08	N.El-Khatib	Lebanon	ACSAD/Damascus	" " "
09	Y. El-Kawasmah	Jordan	ACSAD/Damascus	" " "
10	A.Matar	Syria	ACSAD/Damascus	" " "
11	Z.Ghosheh	Jordan	ACSAD/Jordan	P.O.Box 925860, Amman
12	A.Battikhi	Jordan	University of Jordan	Amman, Jordan
13	I.Saket	Jordan	University of Jordan	Amman, Jordan
14	A.Taimeh	Jordan	University of Jordan	Amman, Jordan
15	B. Sunaa'	Jordan	Natural Resources Authority	P.O.Box 7, Amman
16	N. Haddadeen	Jordan	Ministry of Agriculture - Amman / Jordan	

APPENDIX III cont'd..

TRAINEES :

01	Mr. A.Muhanna	Syria	Ministry of Agric. Syria	P.O.Box 113 Douma, Damascus
02	Mr. I.Dhaiaa'	Syria	Ministry of Agric. Syria	" " " "
03	Dr. H.H.Abdallah	Sudan	Ministry of Agric. Sudan	P.O.Box 388 Wad Madani,Sudan
04	Dr. B. Babikr	Sudan	Ministry of Agric. Sudan	P.O.Box 388 Wad Madani,Sudan
05	Mr. H. Fadi	Sudan	Ministry of Agric. Sudan	" " " " "
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07	M. Abu Talib	Kuwait	Gen.Est.for Agric. Kuwait	P.O.Box 8 (Safat) Kuwait
08	Dr.A. Al-Thor	Yemen	Ministry of Agriculture,Y.A.R	Taiz , Y.A. Republic
09	Dr. A.Mugbil	Yemen	" " "	Y.D.R. University of Aden ,Agr. Fac.
10	A.S. Al-Dukil	Yemen	" " " "	" " " "
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