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Projet Aridoculture

MidAmerica International Agricultural Consortium (MIAC)

U. S. Agency for International Development

SOIL RESOURCE INFORMATION AND AGROTECHNOLOGY TRANSFER IN THE ARIDOCULTURE PROJECT OF MIAC-INRA (KINGDOM OF MOROCCO) A PROPOSAL FOR A RESEARCH AGENDA

by

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and

TROPSOILS-SOIL MANAGEMENT SUPPORT SERVICES

Settat, Morocco,
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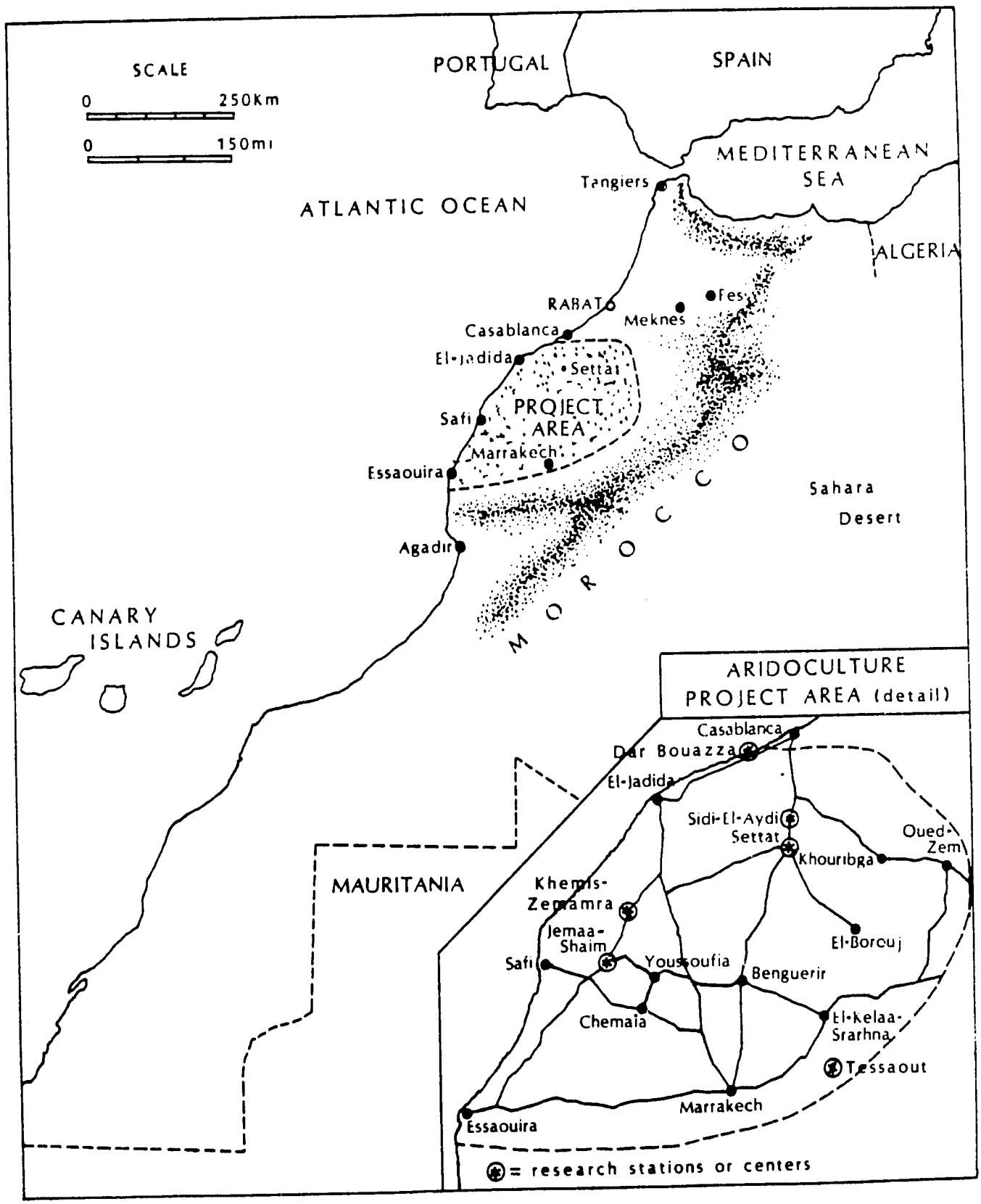
Introduction

The Aridoculture Project of the Institute National Recherche Agronomique (INRA) of the Kingdom of Morocco, and the MidAmerica International Agricultural Consortium (MIAC) funded by the U. S. Agency for International Development (USAID Project No. 608-0136) was initiated in 1978. An impressive center has been established at Settat and a core of highly trained Moroccan personnel is now in place. The broad based research activities has focussed on a variety of constraints which reduce the grain producing capabilities of the region. These include agronomic, plant breeding, disease and pest control research, agrotechnology transfer, soil management, and farm mechanisation. The original thrust was necessarily to solve immediate problems.

The Center is now at a stage to broaden its activities and specifically strengthen additional components which include sustainability of the systems, agrotechnology transfer specifically to the small farmers of the region, and also environmental impacts of current and future technologies. These require base-line information of the bio-physical resource base and long term monitoring. The intent of MIAC is to initiate these activities as the USAID funded project is scheduled to terminate in 1994. The following discussion must be viewed in this light.

In March 1992 (March 7 to 19), Dr. Hari Eswaran, Project leader of the Soil Management Support Services (SMSS) (an AID-S&T/AGR component project of TROPSOIL-CRSP implemented by the Soil Conservation Service-USDA) was invited as a consultant to develop a proposal for the land resource component of the Project. This was a follow-up of a research proposal submitted in 1990 and approved by both MIAC and INRA in 1991 (copy in Appendix I). SMSS has previously collaborated with both INRA and MIAC. In 1983, INRA and SMSS organized a workshop in Morocco for the Arab countries on 'soil survey and classification'. In 1987, SMSS assisted MIAC-INRA in characterizing some of the experimental sites in the Settat area, and in June 1990, this work was continued. The present work was a logical follow-up of these previous collaborative activities.

The Center's staff are constrained by the lack of detailed soils information in the area. Characterization of the soil resource base was considered a national responsibility and beyond the mandate of the MIAC project. The only soil maps available, cover about 20% of the area and are as shown in table 1.


SCALE
0 250Km
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PORTUGAL
SPAIN
MEDITERRANEAN SEA
ATLANTIC OCEAN
Tangiers
ALGERIA
RABAT
Fes
Meknes
Casablanca
El-Jadida
Settat
PROJECT AREA
Safi
Marrakech
Essaouira
Agadir
MOROCCO
Sahara Desert
CANARY ISLANDS
MAURITANIA
ARIDOCULTURE PROJECT AREA (detail)
Casablanca
Dar Bouazza
El-Jadida
Sidi-El-Aydi
Settat
Oued-Zem
Khouribga
Khemis-Zemamra
Jemaa-Shaim
El-Borouj
Safi
Youssoufia
Benguerir
Chemaia
El-Kelaa-Srarhna
Tessaout
Marrakech
Essaouira
= research stations or centers

Region	Map scale	Area (Ha)	No. map sheets	Year
Settat	1:100,000	250,000	1	1985
Abda	1:50,000	340,000	7	1985
Bahira	1:100,000	120,000	1	1983
Settate south	1:100,000	100,000	1	
Doukala	1:50,000	50,000	1	
Total		860,000		
Project area		3,500,000		

Table 1. Available soil maps in Project area

The paucity of information is a major handicap and it is appreciated that to generate the needed information for the project area would require about five years and a large amount of funds. Consequently, for current purposes, Center's staff have expressed the desire to have more generalized information which will provide **'RECOMMENDATION DOMAINS'**. Their current need is basically a map which delineates recommendation domains which could be used for:

1. Selecting sites for technology transfer experiments (on-site evaluation will be made once a general area is designated);
2. Providing a basis for extrapolating results and experience from on-farm trials;
3. Targeting soil moisture and soil conservation activities;
4. Providing a basis for socio-economic surveys;
5. Targeting private-sector activities;
6. For evaluating sustainability programs and impact of research and development activities.

The charge of the consultancy is thus:

To develop a project proposal to produce a map and report that provides sufficient information for:
- **a. general agro-technology transfer;**
- **b. targeting research and developmental activities;**
- **c. providing the basis and highlighting information gaps and needs for future activities.**

INRA and MIAC appreciate the fact that the map and report will only be highly generalized but could serve as a basis for more detailed documentation.

US$ 135,000 is allocated for this task.

Work done during the March (March 7 to 19, 1992) visit

My first task was to reconcile the ideas, expectations, and aspirations of the different individuals. I spent considerable time discussing with individuals to obtain a clear picture of not only on the availability of information but also on what could and needs to be done. I specifically did not constrain these discussions with information on budgetary and time factors. (This part of the discussions was partly influenced by my pre-conceived notion -- arising from my 1990 visit -- that part of the task included the the Ph. D. program of Mr. M. El Oumri). After this assessment, I tried to discuss with the principals again, this time with my opinion and within the budgetary and time limitations.

The individuals I had discussions with include:

a. Staff of INRA-MIAC Center, Settat, which included
   - Dr. Thomas Gillard-Byers, Project Leader, MIAC
   - Dr. Mohamed El Mourid, Director, INRA-Settat (briefly)
   - Dr. John Ryan, Agronomist (extensively)
b. USAID/Rabat
   - Dr. John Mullenax
c. INRA - Rabat
   - Mr. Mohammed El Oumri, Soil Scientist
d. Instituut Recherche Agronomique Hassan II, Rabat
   - Dr. Mohamed Stitou, Professor of Soils

Short trips to the region around Settat were made with Dr. Ryan to recollect some of landscape conditions. I have travelled in the area before. Two soil survey reports were made available and these were:

1. The study of Stitou of the Settat area which has a map at scale of 1:100,000 and a very detailed report;
2. The study of El Oumri of the Abda area, which has maps at scale of 1:50,000 and with an equally detailed report.

Prior to coming to Morocco, I processed the climatic information which we had in Washington D.C. (most of it old) to obtain an idea of the soil moisture and temperature regimes of the project area (Appendix II).

PROJECT PROPOSAL

Purpose:

To develop a map showing the Major Land Resource Areas (MLRA, see Appendix III) of the Aridoculture Project Area and a report giving details of the study. The report will also outline knowledge gaps and suggest areas of future study. The map and report will be a best appraisal based on available information. It is not intended to be a substitute for a detailed soils investigation which is essential and which should be undertaken at the earliest opportunity.

Procedure

Preliminary work to be done in Morocco

The preparation of an MLRA map requires some minimal field investigations particularly because detailed soils information is only available for about 20% of the area. It is hoped that Mr. El Oumri, INRA Rabat, will be largely responsible for providing this information.

About three months of field work (beginning April) is anticipated. It requires travelling around the Project area and recording features and sampling on a random grid pattern. About 2,000 points will be monitored. At each grid point, relevant information will be recorded. A soil sample at a depth of 5 to 25 cm will be taken. The soils will be analyzed by the Aridoculture Centre for the following properties:

pH
Organic carbon, nitrogen
Carbonates
Total and available P and K
Total S
Available Micronutrients

The samples will be sent to the lab in batches so that analysis can commence at the earliest possible time.

During the latter part of this period, Mr. El Oumri will be joined by a soil scientist from the Soil Conservation Service for a period of three weeks. The scientist will traverse the Project area, describe and collect samples, and also provide the Soil Taxonomy classification to each of the points.

It is hoped that the analysis is completed by September 1, 1992. This is the crucial part of the activity. If the analysis cannot

be done in Morocco, arrangements must be made for it to be done by the University of Nebraska at Lincoln.

Work to be done in the US

Processing of the data will be done in the U.S. It is stressed that Mr. El Oumri be involved in at least part of the processing to become familiar with the techniques so that he can apply similar approaches to other problems on his return. Prior to his visit to the US, he will also collate other relevant information necessary for the project. His tentative schedule is:

September -- two weeks -- at the World Soil Resources, SCS, Washington D.C. During this period, he will be involved in spatial analysis of the data, using a pilot area for study. He will also be compiling the basic information for the final report.

September -- two weeks -- at the National Soil Survey Center (NSSC), SCS, Lincoln, Nebraska, and at the Soil Fertility Laboratories of the University of Nebraska. At NSSC, he will have the opportunity to interact with more than 50 soil scientists and be informed about soil survey interpretations, soil analysis, geographic information systems, National Soil Information Systems, etc. At the University of Nebraska, he will have the opportunity to evaluate methods of soil analysis, error detection, confidence limits, and utilization of data.

October -- one month -- I would like to recommend that he spends a month with Dr. Pierre Roberts of the University of Minnesota to obtain hands-on experience with GIS. The Annual meeting of the Soil Science Society of America is scheduled for the first week of November at Minneapolis. He should take the opportunity to attend this and present a poster of his preliminary work. A major part of the work done at Minnesota would be to work on a 'Land Capability Evaluation of the Aridoculture Project Area'. Mr. El Oumri will present a report on the Land Capability Evaluation of the Project Area within six months of his return from the U.S.

The development of the MLRA map and report of the Project area will be handled by the Soil Management Support Services. The assumption is that the grid field study is completed as planned and that all analysis are also completed.

Outputs

The following outputs are envisaged by mid-1993.

1. A report on the Major Land Resource Areas of Project area by SMSS containing the following:

    1. An analysis of soil climate of the project area, employing a theoretical model. A soil climate map at a scale of 1:250,000 or 1:500,000 (depending on density of data) will accompany the analysis. It will be constructed using an interpolation technique and krijging.
    2. A generalized soil map of the area.
    3. Thematic maps showing spatial variations of critical soils properties. (Appendix IV gives some examples with data from the Settat area).
    4. An MLRA map of the Project area with descriptions of the units and explanations on how to use the information.

2. A report on the Land Capability Evaluation of the Project area by Mr. M. El Oumri (INRA).

Illustrative Budget

For operational purposes, the budget has two parts: one dealing with costs in Morocco and the other with costs in the US.

Item	$ U.S.	$ Morocco
Equipment		
Geopositioning system (For INRA)	5,000	
Computer, plotter, printer,etc (For INRA)	15,000	
1:100,000 & 1:500,000 topo-maps		1,000
Sampling accessories		1,000
SPOT Imagery (For INRA)	10,000	
Digitizing and report preparation	40,000	
Services		
Labor and support services		5,000
Fuel, etc. for vehicle		5,000
Soil analysis		20,000
Publication of Land Capability report		3,000
Travel		
Mr. El Oumri to US		12,000
SCS Soil Scientist to Morocco	5,000	
Hari Eswaran to Morocco (March, 1992)	5,000	
Hari Eswaran to Morocco (1993)	5,000	
Contingencies	3,000	
Total	88,000	47,000
GRAND TOTAL	**U.S. $ 135,000**	

Appendix I

MIAC RESEARCH PROPOSAL

MAPPING PROJECT PROPOSAL TO USAID

DEVELOPMENT OF A SCHEMATIC SOIL-LAND CAPABILITY MAP FOR TECHNOLOGY TRANSFER IN THE ARIDOCULTURE CENTER'S ZONE OF INFLUENCE

by

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Since its inception, the Aridoculture Center in Settat has focused on developing technologies that can be readily adopted by the predominately small-scale farmers throughout the vast arid and semi-arid area (4 million hectares cultivated) under its mandate. While this area can be classified into three broad agro-ecological zones based on rainfall and temperature data, characterization of soil in these zones is non-existent to rudimentary at best for most of the area; only a small proportion is satisfactorily mapped. Successful implementation of useful technologies at the farmer's level requires a recognition of recommendation domains which account for climatic and soil diversity. The recommendation domain should be large areas for transfer of technologies such as water conservation, fertilizer use, varieties, and management practices according to rainfall and soil properties, such as depth and texture.

It is instructive to examine the extent to which the region's soils are known and mapped, either at the higher intensity local level or the larger scale regional level. The soils at the experimental stations, where potential technologies are developed are comparatively well identified - with simple maps available for Sidi El Aydi (Typic Calcixeroll, Vertic Palexeroll), and Jemaa Shaim (mainly Typic Chromoxerert with some shallower Petrocalcic Palexeroll). Chromoxererts dominate at Khemis Zemamra and at Jemat Riah, while Ain N'Zagh varies from Petrocalcic Palexerolls to Argixerolls. With the possible exception of the latter station, the experimental stations are located on the region's better and deeper soils. However, a disproportionate amount of the dryland zone does not involve these soils. Recognition of these discrepancies in addition to the fact that fertility levels at stations are considerably higher than in farmers' fields (Ryan et al., 1990) led to increased emphasis towards on-farm research. Ideally, this provides a more meaningful basis for technology transfer.

Fertilizer use, notably nitrogen and to lesser extent phosphorus, lends itself readily to farmer adoption. However, our work at the Center (Soltanpour et al., 1989; Ryan et al., 1990) showed that crop responses were

not only related to major rainfall zones, but within any zone yield potential could differ two-to threefold as a result of soil differences (Abdel Monem et al., 1990. Our findings with deep (Vertisols), moderately deep (Calcixerolls), and shallow soils (Petrocalcic Palexerolls) enables us to generalize to most of the Chaouia region since these soils represented at least 60% of that area. That the Chaouia area is mapped (Stitou, 1986) at the 1:100,000 level provides the basis for this generalization. Technologies other than fertilizers are no less sensitive to soil varieties within any climatic zone.

However, less than 25% of the cultivated dryland project area is characterized by a soils map to any extent. In addition to the Chaouia area ($240x10^3$ hectares), other areas mapped include Doukkala ($60x10^3$ ha, irrigated), Abda ($350x10^3$ ha) and Bahira ($120x10^3$ ha), all at a scale of 1:50,000. Despite these efforts, soils of the greater part of the Project zone, where farmers or the end-users of our developed technologies, remain uncharted.

Casual observations would suggest that, within any rainfall zone, large areas of diverse soil types exist. For example, while deep Vertisols are extensive in the Settat-Oulad Said area and again in the south at Jemaa Shaim, a vast area of red sandy soil extends from Boulaouane to Khemis Zemamra. Recommendations for fertilizer use - indeed any technology - would have to consider such differences.

Thus, a prerequisite to successful transfer of technology is information on the soil resource. The issue is one of scale - and that involves time and money. While a medium-intensity survey of the Project zone would be desirable (1:25,000), this would take many years to complete and be prohibitive in terms of labor and financial resources. Even low intensity maps such as that of Stitou (1985) for Chaouia at 1:100,000 is time - and resource-consuming; Other than its general utility in helping select trial sites for on-farm research, its utility has been limited.

Given the area's low output and the urgency to address it, it is probable that a schematic-reconnaissance type map of the Project area at 1:250,000 would suffice. This should, 1) delineate climatic zones, 2) identify major soil groups or orders in these zones and, 3) broadly classify the area in terms of land use capability and cropping systems.

Such a map could be constructed based on available satellite and aerial photos, topographical and geological maps, extensive ground observations of the soil distribution, the landscape and associated cropping systems, and available rainfall and temperature data, and exposure of profiles of "benchmark" or major soil orders. The major soils types will be identified in local vemacular terms.

The output of the effort, which should be completed in 9-12 months, would be a limited number of well-defined recommendation domains. This would greatly assist selection of sites for on-farm research in each domain and help to make the ensuing research findings more meaningful, and target technologies to fitted environments.

While the Project will be mainly carried out by INRA, it will involve IAV which has considerable expertise in satellite imagery of the Settat area. The budget of $135,000 is attached.

In summary, the beneficiaries of the project will include:

1. Researchers at the Aridoculture Center whose effort at technology transfer will be enhanced,

2. Agents from local DPA and CD Centers who can more effectively make recommendations to farmers.

3. Ultimately, the farmers of the dryland region who are the recepients of developed technologies, and

4. Institutions such as INRA and IAV-Hassan II, which will benefit from such collaborations.

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Appendix II

INFORMATION OF PROJECT MIAC AREA

The physiographic environment

The Project area (Fig. 1) is about 35,000 Km^2 stretching from about Casablanca in the north to just south of Safi in the south. The area covers 10 provinces of southern Morocco. These are the provinces of Settat, Khouribga, Marakesh, El Kalaa, Casablanca, Ben Slimane, Safi, El Jadida, and small parts of d'Essaouira Nord-est and Beni-Mellal l'ouest. The tectonic basin is bounded on the east and south east by the Middle Atlas range and the north by the foothills of the same range. The Atlantic coastal plain forms the western limit of the area. The area is characterized by a series of plateaus which are situated at different elevation levels. The elevation decreases in a south westerly direction. Around Settat, where the Aridoculture Center is located, the elevation is around 375m while near Sidi Bennour, it is only about 183m. The marked elevation differences of the different plateaus and their locations result in micro-climatic differences, both in terms of temperature and precipitation.

The area has a Mediterranean climate, characterized by winter rainfall, and with mild winters and hot and dry summers. Such a climatic environment is distinctly different from the 'semi-arid tropics' and is to be found as a narrow belt along the Mediterranean coast of North Africa and a small zone in South Africa, around Cape Town. In this respect, this is an unique climatic environment. As in most semi-arid environments, the climate is characterized by a very irregular distribution of precipitation and in addition, a significant part of the precipitation comes as a few intense storms. The coefficient of variability of the rainfall is expected to be high (no calculations have been made) and is expected to range from about 0.2 to 0.4. The total precipitation decreases in a north-south trend. Preliminary computations, by the author, of soil moisture regimes suggest the following trends as shown in table 2.

Name	Growing Season Beginning	End	Length	MSSI
Tanger*	Oct. 16	Jul. 29	284	0.26
Rabat*	Nov. 16	Jul. 20	245	0.37
Midelt*			0	1.00
Khouribga	Nov. 16	Jul. 4	229	0.41
Oued Zem	Nov. 16	Jul. 3	228	0.44
Settat	Nov. 16	Jul. 2	227	0.44
Kasba Tadla	Nov. 16	Jun. 27	222	0.46
Berrechid	Nov. 16	Jun. 20	215	0.47
Sidi Bennour	Nov. 16	May. 29	194	0.58
El Jedida	Nov. 16	May. 30	195	0.64
Safi	Nov. 16	May. 20	185	0.66
El Kelaa	Jan. 16	May. 5	110	0.80
Marrakech	Feb. 16	Apr. 6	51	0.91

Table 2. 50% probability estimates of beginning, end, and length of growing season, and the Moisture Stress Severity Index (MSSI). * Stations for comparison.

A more detailed analyses of the climatic environment can be made if long term climatic records are available. Such an analysis must be made to design cropping systems to synchronize with the climate and also to test farming systems designed to circumvent the vagaries of the climate. A better appreciation of climatic events, particularly storm events, intensity and periodicity of storms, are necessary for both soil and moisture conservation programs. Climatic data on a daily basis is needed for this analysis.

The soil patterns in the Project area appears to be relatively simple. The soils in the area are formed largely as a function of the parent rock or material. Peneplanation has been an active geologic process in the area and the plateaus are either denudational or aggradational features. Dissection of the higher level plateaus is still active and most evident at the peripheries. Superimposed on the effects of the parent material is the influence of the climate. The major soils of the region belong to the following kinds (Appendix V lists the classification of the soils in the two surveyed areas):

Vertisols: there are large contiguous areas of the Vertisols which are present generally on local depressions. These are the black soils which are generally more than 50 cm deep and which on drying become very hard with deep cracks. On wetting, the soil material swells and becomes very sticky. Tillage can only be done at optimum moisture conditions between these extremes. There are some with rock at depths of 50-100 cm but most are deeper than 100 cm. These soils have an available water holding capacity of about 100

mm and for most practical purposes, 1cm of the soil can be considered to hold about 1 mm water.

Alfisols: these are the reddish soils. On some plateaus, their texture is loamy with about 25 to 35% clay. The surface 25 cm has less clay and at 25 cm depth, there is a marked clay increase. These are favorable properties; the lighter textured surface horizon permits easy tillage while the heavier subsoil can store more water. The available water to a 1m depth is generally about 150mm or 1cm of soils holds about 1.5mm of water. Depth of soil is important criteria in these soils. The subsoil may be underlain by hard rock or by petrocalcic horizon. Although the origin of the two is different, their behavior for management is the same -- both are impermeable to water and roots.

A variant of these typical Alfisols, and this occurs as a large area around Sidi Bennour, are the sandy soils. (No detailed description is available and the following is a preliminary assessment). I suspect that they are also Alfisols (some may be Entisols -- Psamments) but due to their sandy textures are very drought prone. They would probably have an AWHC of about 50 mm or 1 cm will hold about 0.5mm of water. With irrigation they are good peanut soils but in the absence of irrigation, they can be used for crops that tolerate moisture stress, such as grapes.

Some of the Alfisols may be stony, both in the soil and on the surface, requiring greater energy for tillage. The stoniness does not reduce the quality of the soil.

Alfisols are some of the best soils of the region and, apart from moisture stress, can be most productive soils. They are also highly erodible and they require good conservation practise. With good land use, they can sustain the society for generations; with poor land use, they can be destroyed in one generation.

Mollisols: these are the other black soils of the region and characterize much of the area around Settat. They generally form under cool environments and with adequate rainfall. The river Oued Oum El Rbid, running south of Settat, marks the southern boundary of the Mollisols in western Morocco. South of the river, the soils are too dry or too hot to have conditions favorable for formation of the mollic surface horizon.

The Mollisols (or prairie soils or Chernozems), when deep, are some of the most productive soils of the world. However, in the Settat area, most of the Mollisols are shallow and are underlain at depths of 25 to 50 cm., with either hard rock or a petrocalcic

horizon. A 1m deep clayey Mollisol can hold about 200 mm of water or about 2mm per cm of soil. The organic matter of the surface horizon is generally above 1.5% and may be as high as 5%. The high organic matter is a very favorable property and conservation of the organic matter is vitally important for the continued good performance of the soil.

Inceptisols: bordering the Project area, on the steeper terrain, are shallow soils or even bare rock. These are potential areas for reforestation; grazing or agriculture must not be permitted.

Aridisols: South of Ben Guerir, towards Marrakech the aridity increases markedly. There is also concomitant changes in the soils. Soils are shallower, vegetation is sparse and consequently land use is largely grazing. This is the region of the Aridisols. Unless high technology is available, these Aridisols must be kept under their natural conditions and any form of agriculture must be discouraged.

Soil Microvariability: Although the general soil pattern is relatively simple, there is considerable microvariability in the soils. Such variability can only be established by detailed mapping. The microvariability must be known for on-farm trials, particularly for plant breeding trials.[1]

Nutrient status: Much of the Project area is influenced by soils derived from phosphate rich rocks, particularly the limestones. In some areas as in the Plateau de Phosphate, there is sufficient concentration for mining. The mines are also a source of pollution of the adjoining areas. Consequently, many of the soils have high to excessively high levels of phosphate. There is very little agronomic experience on high phosphate soils and in fact few investigations have looked at crop performance and nutrient interactions from this point of view. There is an urgent need first to make a detailed nutrient survey and later to evaluate the impact of high phosphates on nutrient interactions, availability, and role on crop performance. Such studies will be useful not only to Morocco but also to many countries in the Mediterranean region where similar situations occur. Table 3 provides information for some soils. There is a wide range of phosphate content. The available phosphate ranges from almost 0 to more than 250 ppm in the Settat area. As seen in the table, the available P is not related to total. Some of the high P values may be related to fertilization but when the values are

1 See also Report of Eswaran (1990)

considered as a depth function in the soil, particularly for the high phosphate soils, the consistent high values indicates that it is an inherent feature of the soil. Studies of high phosphate soils in Kansas shows formation of secondary phosphate minerals, such as Crandellite which have low solubility in a high pH environment.

Profile No. (Soil map Settat)	Map Unit No.	Available P_2O_5 (Olsen's)	Total P_2O_5	Available K_2O
1117	30	40	140	1,076
1187	51	14	480	280
738	3	9	850	304
138	32	98	1,150	310
267	8	83	1,550	209
686	17	23	3,400	159
1209	43	154	3,600	234
1079	24	146	11,880	514
241	18	85	13,600	141
997	31	188	17,200	608
815	33	181	200,000	56
(Soil map of Abda)				
2560	7	41	1,370	436
3380	8	28	3,220	419
2492	10	0	1,400	128
2494	11	41	3,000	339
3852	12	40	700	37
50B	19	11	3,837	270
1106	28	16	1,065	385
1225	32	1	550	1
840	39	63	4,720	91
73	43	1	900	278
1583	47	13	1,250	483

Table 3. Available and total phosphates, and available potassium, in some soils of the Project area (Data from Soil Survey Reports.

The available phosphates is very high (if analysis is correct) in most of the soils (table 3). The soils derived from quartizitic shales (profile 1117) appear to have high potassium and this is from the mica minerals in the rock. Limestones also have micas as impurities and the amounts are variable. The very low value in profile 1225 may be an error.

Appendix III

CONCEPT OF MAJOR LAND RESOURCE AREAS

MLRA maps are used at national levels:

1. as a basis for making decisions about agricultural issues;

2. as a framework for organizing and conducting resource conservation programs;

3. for geographic organization of research and conservation needs and the data from these activities;

4. for coordinating technical guides between states and districts of a nation and between countries;

5. for organizing, displaying, and using data in physical resource inventories, and

6. to aggregate natural resource data.

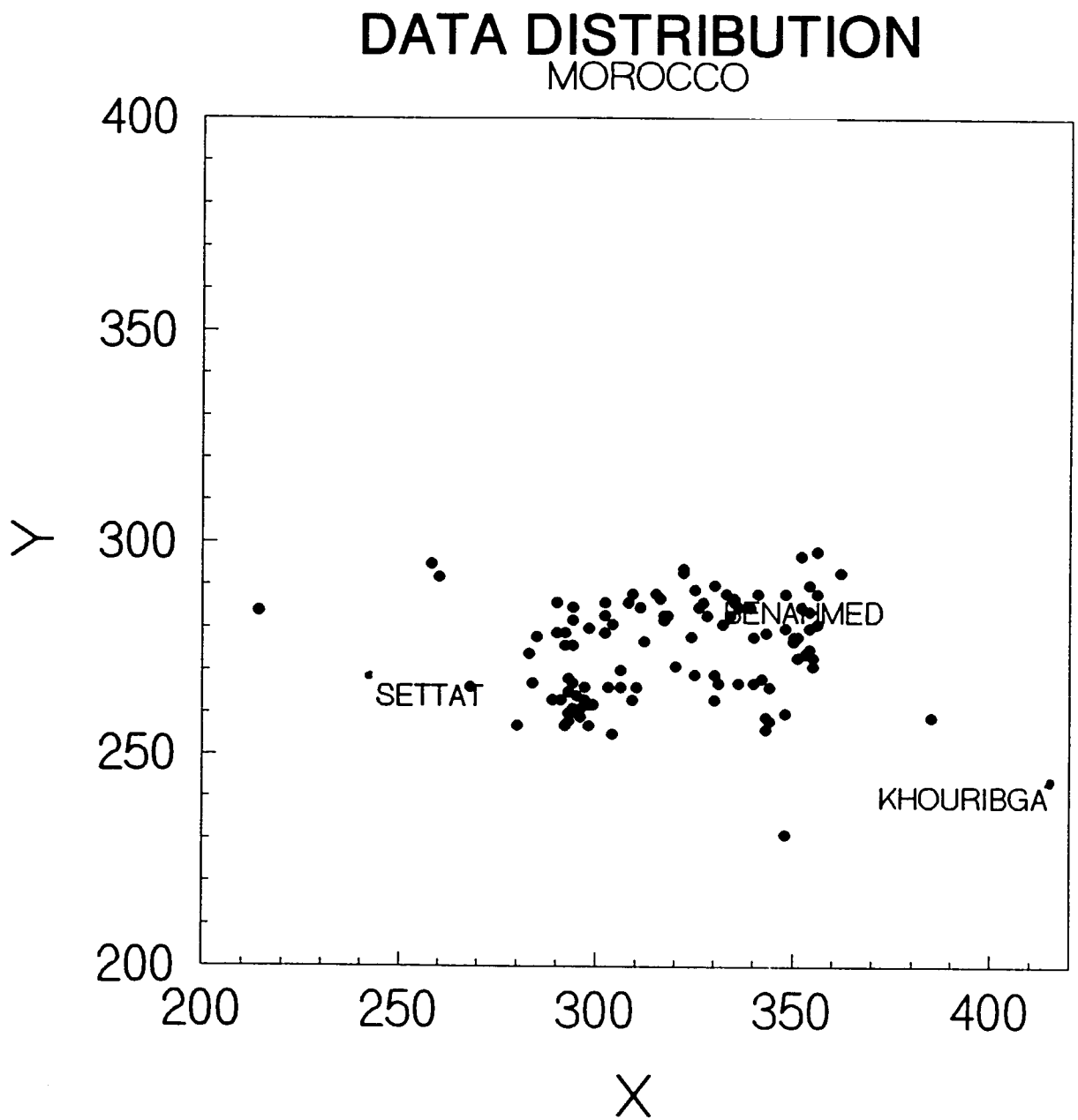
MLRAs are most important for agricultural planning and have value for interstate, regional, and national planning.

Appendix IV

STUDY OF DISTRIBUTION OF SOME PROPERTIES OF SOILS OF THE SETTAT AREA

A soil map (scale 1:100,000) and report of the Settat area is available. Data for about 80 soils are presented in the report. Available data was used to generate the single property thematic maps shown in Figs. 1 to 4, as an illustration. In Fig. 1, the sampled areas are shown and the uneven distribution of the data points make the remaining figures unreliable and questionable. The only reason these figures are included in this report is to illustrate the principle of the technique.

In the absence of detailed soil maps, kriging techniques are very useful to obtain an assessment of limiting or useful properties.


DATA DISTRIBUTION
MOROCCO
400
350
300
250
200
Y
200
250
300
350
400
X
SETTAT
BENAHMED
KHOURIBGA

19

Fig. 1.

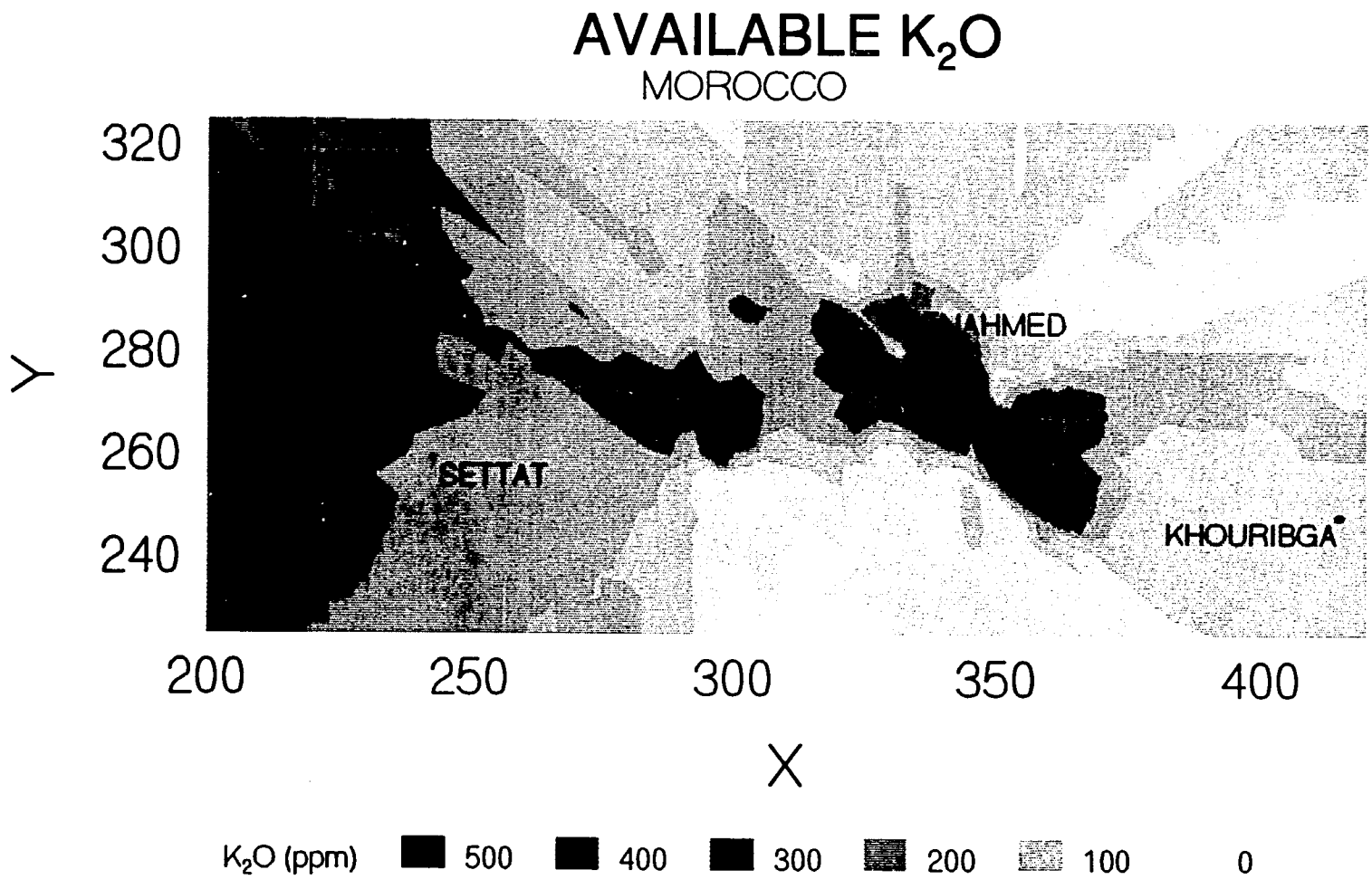

AVAILABLE K_2O
MOROCCO
320
300
280
260
240
Y
200
250
300
350
400
X
SETTAT
AHMED
KHOURIBGA
K_2O (ppm)
500
400
300
200
100
0

Fig. 2.

20

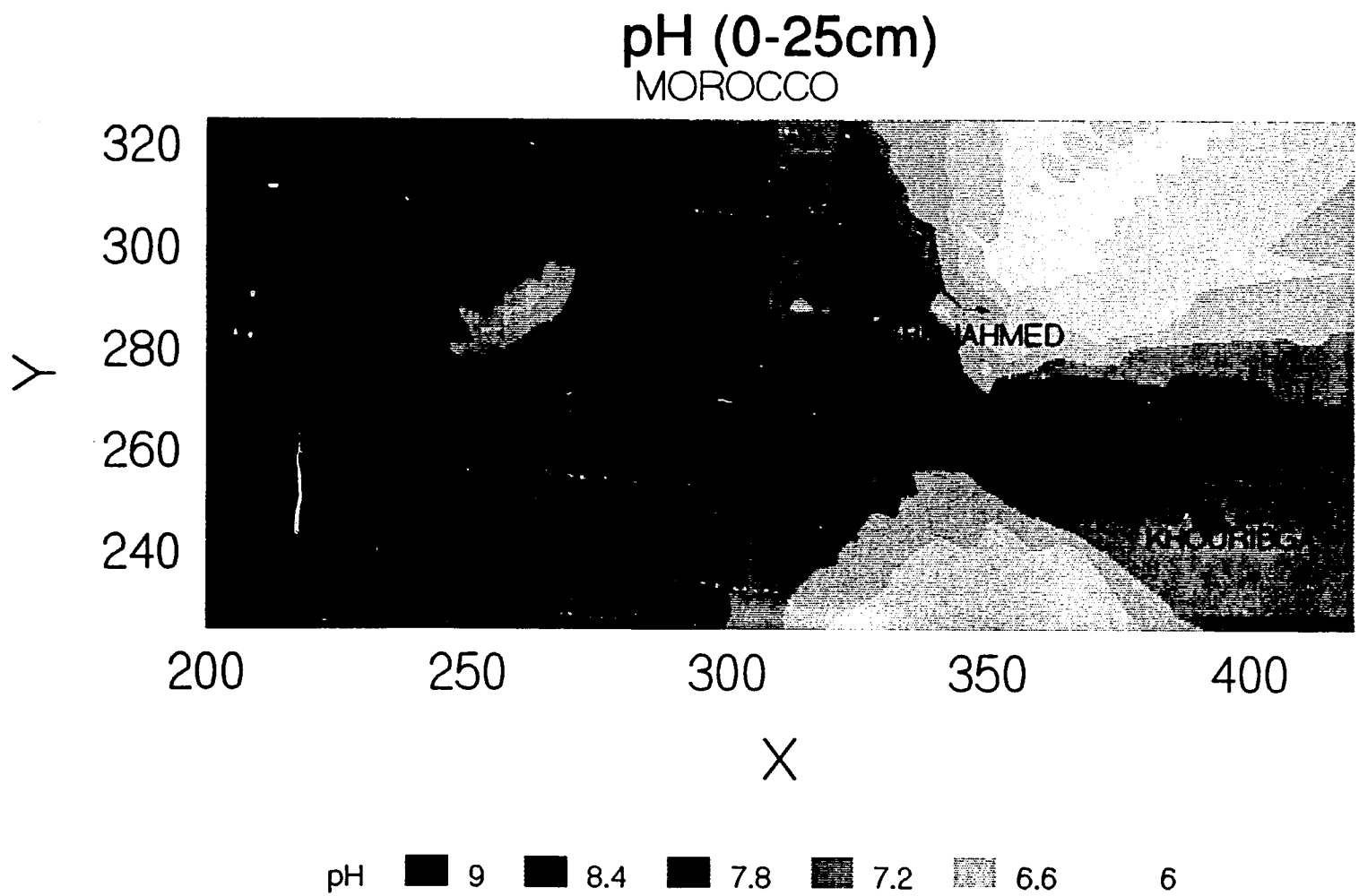

pH (0-25cm)
MOROCCO
320
300
280
260
240
Y
200
250
300
350
400
X
AHMED
pH
9
8.4
7.8
7.2
6.6
6

Fig. 3

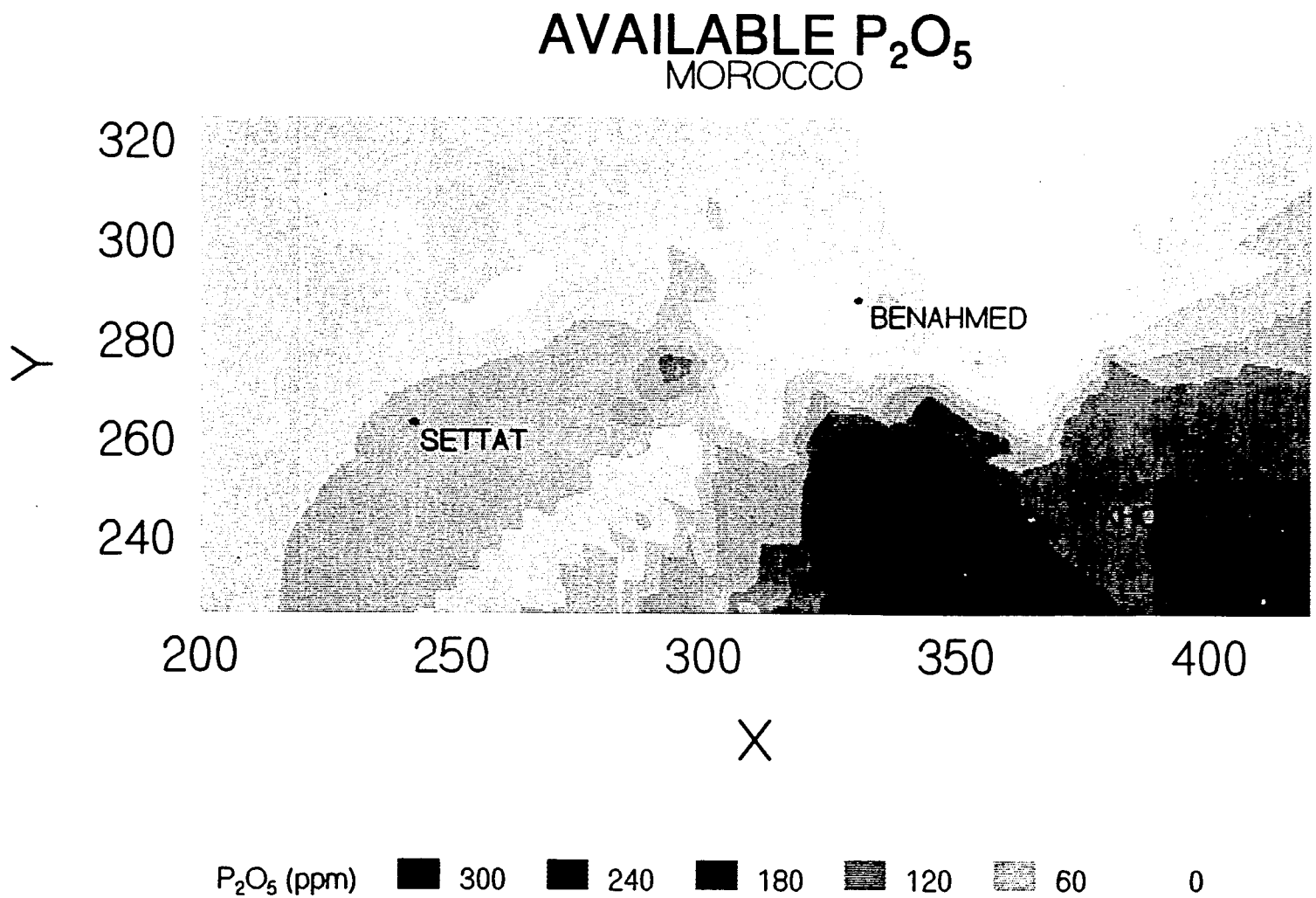

AVAILABLE P_2O_5
MOROCCO
320
300
280
260
240
Y
BENAHMED
SETTAT
200
250
300
350
400
X
P_2O_5 (ppm)
300
240
180
120
60
0

Fig. 4

22

Appendix V

CLASSIFICATION OF MAJOR SOILS OF MIAC PROJECT AREA

Two semi-detailed soil surveys were conducted in the Project area. The first, at scale 1:50,000, was in the Abda region by Mr. El Oumri and his staff of INRA and the second, at scale 1:100,000, by Mr. Stittou and his staff from Instituut Agronomique Hassan II. In each study a large number of soils were described and analyzed. This report attempts to classify the soils according to Soil Taxonomy. As methods of description and sampling varied from the procedure of the Soil Conservation Service, USDA, the following classification is considered tentative.

The Soil Taxonomy classifications are provided for those who do not appreciate the French classification given in the reports.

A. ABDA AREA

Map Unit	Classification
7	Fine-loamy, mixed, thermic, shallow, Petrocalcic Palexeroll
8	Fine-loamy, mixed, thermic, Lithic Xerochrept
9	Coarse-loamy, mixed, thermic, Typic Xerochrept
10	Coarse-loamy, mixed, thermic, Typic Xerochrept
11	Fine, Mixed, thermic, Typic Xerorthent
12	Fine, mixed, thermic Haplic Palexeralf
13	Sandy, carbonatic, thermic, Typic Palexeralf
14	Thermic, Lithic Xeropsamment
15	Loamy-skeletal, mixed, thermic, shallow, Petrocalcic Palexeroll
16	Fine-loamy, mixed, thermic, shallow, Petrocalcic Palexeroll
17	Fine-loamy, mixed, thermic, shallow, Petrocalcic Palexeroll
18	Fine-loamy, mixed, thermic, shallow, Petrocalcic Palexeroll
19	Loamy-skeletal, mixed, thermic, shallow, Petrocalcic Palexeroll
20	Loamy-skeletal, mixed, thermic, shallow, Petrocalcic Palexeroll
21	Loamy-skeletal, mixed, thermic, shallow, Petrocalcic Palexeroll
22	Loamy-skeletal, mixed, thermic, shallow, Petrocalcic Palexeroll
23	
24	Loamy-skeletal, mixed, thermic, Lithic Haploxeroll
25	Loamy-skeletal, mixed, thermic, Lithic Haploxeroll
26	Loamy-skeletal, mixed, thermic, Lithic Haploxeroll
27	Coarse-loamy, mixed, thermic, Calcixerollic Xerochrept
28	Clayey-skeletal, mixed, thermic, Calcic Haploxeroll

23

29 Fine-loamy, mixed, thermic, Calcic Haploxeralf
30 Fine-loamy, mixed, thermic, Calcic Haploxeralf
31 Fine-loamy, mixed, thermic, Calcic Haploxeralf
32 Fine-loamy, montmorillionitic, thermic, Typic Pelloxerert
33 Fine-loamy, montmorillionitic, thermic, Typic Pelloxerert
34 Fine-loamy, montmorillionitic, thermic, Natric Haplaquert
35 Fine-loamy, montmorillionitic, thermic, Entic Pelloxerert
36 Fine-loamy, montmorillionitic, thermic, Typic Chromoxerert
37 Fine-loamy, mixed, thermic, Petrocalcic Xerochrept
38
39 Fine-loamy, mixed, thermic, Typic Haploxeralf
40 Fine-loamy, mixed, thermic, Typic Haploxeroll
41 Fine, mixed, thermic, Mollic Haploxeralf
42 Fine-loamy, mixed, thermic, Calcic Haploxeroll
43 Fine, montmorillionitic, thermic, Vertic Haploxeroll
44 Fine, montmorillionitic, thermic, Vertic Haploxeroll
45 Loamy-skeletal, mixed, thermic, Typic Camborthid
46 Fine, mixed, thermic, Calcic Rhodoxeralf
47 Fine, mixed, thermic, Calcic Rhodoxeralf
48 Fine, mixed, thermic, Calcic Rhodoxeralf
49 Remaining units are complexes

B. SETTAT AREA

Map Unit	Classification
1	Fragmental, thermic, Lithic Xerorthent
2	Loamy-skeletal, mixed, thermic, Lithic Xerorthent
3	Fine, mixed, thermic, Calcixerollic Xerochrept
4	Fine, mixed, thermic, Typic Argixeroll
5	Loamy-skeletal, mixed, thermic, Lithic Xerorthent
6	Loamy-skeletal, mixed, thermic, Lithic Haploxeroll
7	Loamy-skeletal, mixed, thermic, Typic Haploxeralf
8	Fine-loamy, mixed, thermic, Typic Xerochrept
9	Fine, montmorillionitic, thermic, Entic CHromoxerert
10	Very fine, montmorillionitic, thermic, Palexerollic Chromoxeret
11	Fine, montmorillionitic, thermic, Palexerollic Chromoxerert (Oulad Said Experimental Plots)
12	Loamy-skeletal, carbonatic, thermic Calcic Haploxeroll
13	Fine, mixed, thermic, Typic Haploxeroll
14	Loamy-skeletal, carbonatic, thermic, Calcic Haploxeralf
15	Loamy-skeletal, mixed, thermic, shallow, Petrocalcic Xerochrept SCS Pedon Data:
16	Fine, mixed, thermic, Petrocalcic Palexeralf
17	Clayey-skeletal, mixed, thermic, Calcic Xerochrept

24'

18 Clayey-skeletal, mixed, thermic, Calcic Argixeroll
19 Loamy-skeletal, carbonatic, thermic, Calcic Argixeroll
20 Clayey-skeletal, mixed, thermic, Calcic Haploxeroll
21 Clayey-skeletal, mixed, thermic, Calcic Argixeroll
22 Clayey-skeletal, mixed, thermic, Calcic Argixeroll
23 Clayey-skeletal, mixed, thermic, Calcic Argixeroll
24 Clayey, mixed, thermic, Entic Chromoxerert
(Jemmat Riah Research Station, INRA)
25 Clayey-skeletal, mixed, thermic, Calcic Argixeroll
26 Clayey-skeletal, mixed, thermic, Typic Calcixeroll
27 Clayey-skeletal, mixed, thermic, Typic Calcixeroll
28 Clayey-skeletal, mixed, thermic, Typic Calcixeroll
29 Clayey-skeletal, mixed, thermic, Typic Calcixeroll
30 Clayey-skeletal, mixed, thermic, Typic Argixeroll
31 Clayey-skeletal, mixed, thermic, Typic Xerochrept
32 Clayey-skeletal, mixed, thermic, Typic Calcixeroll
33 Loamy-skeletal, mixed, thermic, Typic Argixeroll
34 Fine-loamy, carbonatic, thermic, Typic Calcixeroll
(Sidi El Aidi Station, SCS Pedon No. 004)
Fine, montmorillionitic, thermic, Vertic Palexeroll
(Sidi El Aidi Station, SCS Pedon No. 005)
35 Clayey-skeletal, mixed, thermic, Vertic Argixeroll
36 Clayey-skeletal, mixed, thermic, Typic Palexeralf
37 Clayey-skeletal, mixed, thermic, Typic Palexeralf
38 Clayey-skeletal, mixed, thermic, Typic Palexeralf
39 Clayey-skeletal, mixed, thermic, Typic Argixeroll
40 Clayey-skeletal, mixed, thermic, Typic Haploxeralf
41 Clayey-skeletal, mixed, thermic, Vertic Rhodoxeralf
42 Clayey-skeletal, mixed, thermic, Typic Argixeroll
43 Clayey-skeletal, mixed, thermic, Typic Palexeralf
44 Clayey-skeletal, mixed, thermic, Typic Palexeralf
45 Remaining units are complexes