PN-ACF-137

PROJET

MRT

TADLA RESOURCES
MANAGEMENT

[redacted]

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MICRO IRRIGATION IN THE TADLA PERIMETER

Report No 36

Prepared by

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March 1996

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EXECUTIVE SUMMARY

The main purpose of this consultancy was to advise and assist Projet Management des Ressources du Tadla (MRT) an d l'Office Regional de la Mise en Valeur Agricole du Tadla (ORMVAT) personnel with an assessment of the current state of micro-irrigation in the Tadla Perimeter focusing on the potential utility of the various methods under local on-farm existing constraints as opposed to surface irrigation techniques

Selected farms with micro-irrigation systems and suppliers of equipment were visited and interviewed There is a high level of interest in selling micro-irrigation equipment in the Tadla Perimeter The challenge, therefore, is not how to promote micro-irrigation but rather how to promote the appropriate use of micro-irrigation, especially in conjunction with the marketing of high-value crops

A reconnaissance-level economic comparison of micro-irrigation to Robta and level basin irrigation techniques reveals that, although micro-irrigation by far has the largest initial capital cost, it also has the potential to realize the greatest crop yields and water savings It is strongly recommended to thoroughly examine the economics on a farm-by-farm basis prior to the decision to purchase micro-irrigation equipment.

Major impediments to micro-irrigation success in the Tadla perimeter include the large initial capital investment required, the difficulty of successfully transferring micro-irrigation technology to the on-the-farm level, and the farmer's ability to recoup the investment (i e , the ability to develop a marketing program to ensure necessary profit levels)

Specific comments on existing Tadla Perimeter micro-irrigation systems address filtration, pressure regulation, purge valves, maintenance, isolation valves, PVC pipe installation, ajutage, micro-sprinklers, and the conversion of mature orchards

SECTION I
INTRODUCTION

A Purpose and objectives

The main purpose of the consultancy was to advise and assist Project Management de Ressources du Tadla (MRT) and l'Office Regional de la Mise en Valeur Agricole du Tadla (ORMVAT) personnel with an assessment of the current state of micro-irrigation in the Tadla Perimeter, focusing on the potential utility of the various methods under local on-farm existing constraints as opposed to surface irrigation techniques

B A Summarization of Activities During the Consultancy

The author was on-site at the MRT offices in Fquih Ben Saleh from 27 February through 15 March 1996 The first week was spent becoming familiar with micro-irrigation situation through discussions with MRT and ORMVAT personnel and by site visits to selected farms The SEHA Ouled Gnaou Station, and the SATA, and Kaitouni farms were toured

During the second week, the major activities included interviewing micro-irrigation dealers in Casablanca and Rabat (CMGP, Irri-Serra, TECHNOV, and MGG) Additionally the Laboratoire de l'Hydraulique Agricole et de la Normalisation was toured in Rabat. The Lahmam farm in the Tadla perimeter was also toured Spreadsheets were developed to perform reconnaissance-level economic evaluations of selected irrigation techniques on potatoes and mature citrus Training outlines were developed for the design seminars in anticipation of conducting the seminar during the fourth week It became apparent that much of the developing micro-irrigation techniques were coming out of the Marrakech area Therefore, a tour of selected micro-irrigation installations near Marrakech was arranged for the third week

SECTION II
BACKGROUND

The Tadla Perimeter of Morocco is generally west of the Middle Atlas Mountains, about 200 kilometers (km) inland from Casablanca It encompasses approximately 94,000 hectares (ha) of irrigated agriculture Water sources are surface water from Oued Rbia and Bin Alwidane Dam and groundwater The ORMVAT is the primary administrating agency for agriculture and the environment in the Tadla region and is headquartered in Fquih Ben Salah Major crops include citrus, wheat, corn, olives, stone fruit and vegetables

The reader is referred to section II, Background in Improvement of Surface Irrigation Systems in the Tadla Irrigation Project (Projet MRT Report No 22, Allen Dedrick, April 1994) for a more thorough description of the Tadla Irrigated Perimeter, typical farm layout, water delivery policies, and agronomic issues

SECTION III
MICRO-IRRIGATION SYSTEMS

A Introduction

The following definitions and typical system description are based on the author's experience in the United States Figure 1 shows the general system components

Micro-irrigation systems are defined as pressurized systems which deliver water directly to the plant, typically through a series of water regulating devices known as emitters or micro-spiklers **Emitters** typically produce a stream or drip of water, where **micro-sprinklers** act as small sprinklers and discharge the water as a spray Emitters typically operate under low pressures, 1/2 to 31/2 bars, and low flows, 2 liters per hour (1/hr) to 16 l/hr Similarly, micro-jets also typically operate under low pressures, 3/4 to 2 bars, and low flows, 20l /hr to 100 l/hr

Typically emitters are more widely used, with micro-sprinklers having specific applications in sandy soils and orchards where frost protection is needed

Two major types of micro-irrigation systems may be found in the Tadla Perimeter **drip** (goutte à goutte) and **micro-sprinklers** (microjet) Drip irrigation is comprised of emitters with flows of less than16l /hr Drip irrigation emitters may either be extruded as an integral part of the tubing or manufactured and installed separately Most micro-irrigation systems have emission devices installed on polyethylene tubing

High flow (ajutage) irrigation systems are also found in the Tadla perimeter This type of system does not fit the conventional definition of micro-irrigation in that it operates with emission device flows of between 20 and 130 l /hr Ajutage sacrifices the precision of other micro-irrigation methods in order to minimize clogging problems

In order to achieve the low flows utilized in micro-irrigation, the emission devices typically have small orifices through which the water is discharged in a regulated fashion Filtration, therefore, is an absolute necessity to keep the emission devices unclogged and functioning **Filtration** typically consists of a fine-mesh screen, collection of disks, or sand through which the water must pass under pressure

Most micro-irrigation systems also have control valves, some sort of pressure regulating device, fertilizer injectors, purge valves, and other appurtenances necessary to connect all the components A pump is usually required to pressurize the system Usually the water will be conveyed through a **mainline**, consisting of polyvinyl chloride (PVC) pipe, to the operating blocks in the field An **operating block** is merely that portion of a field which is irrigated by a

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Figure 1
Typical Micro-Irrigation System Schematic

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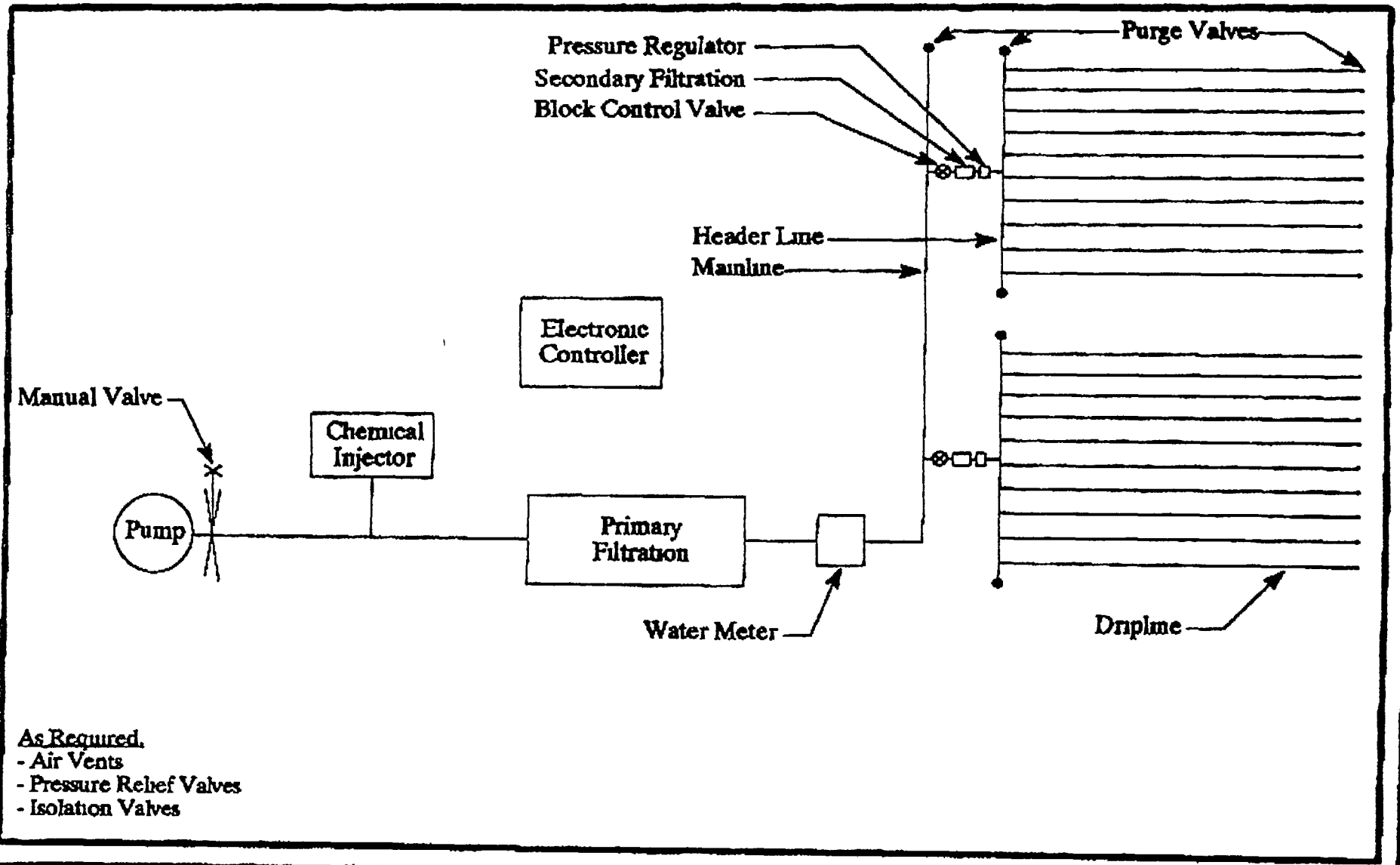

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single **control valve** Although they may be manually or hydraulically activated, typically the control valves are electrically activated

The control valve is typically accompanied by a pressure regulating device and a secondary filtration device The control valves regulates the flow of water into the **header line**, typically a PVC pipe to which the driplines are connected The driplines are usually made of polyethylene (PE), are flexible, and have either the emission devices, or smaller PE "spaghetti" tubes which lead to the emission devices, punched or extruded into them The PE **driplines** deliver the water down the rows and to the plants Assorted fittings are required to connect all of these components together into a functioning system

The ability to keep all of these components clean and free of debris and particulate dictates the inclusion of purge valves at the end of the mainline, header lines and driplines

If the control valves are automatically (either electrically or hydraulically) actuated, a **controller** is required, which turns the control valves on and off

B Advantages of Micro-Irrigation Systems

Micro-irrigation technology has enjoyed increasing use world-wide in the past several decades It has many advantages which include the following

- Increased yields,
- Improved crop quality,
- Less water use and better water penetration,
- Less fertilizer use,
- Lower energy costs (compared to sprinklers),
- Less labor cost,
- Less herbicide use,
- Less likelihood of disease,
- More efficient harvesting,
- Ability to irrigate on slopes and uneven terrain,
- Ability to use more saline water, and
- Decreased drainage problems

C Problems Typically Associated with Micro-Irrigation

No irrigation method is without drawbacks, and micro-irrigation is no exception. The primary disadvantages include the large initial capital cost of the equipment and the difficulty of managing these unique types of irrigation systems Because of these concerns, micro-irrigation is typically limited in application by economics and level of farmer sophistication The important considerations when considering micro-irrigation include the following

- High initial capital cost,
- Increased sophistication of technology,
- Irrigation management very different than surface or sprinkler irrigation management,
- Less margin for error in amounts and timing of water applied,
- Emission orifices very small and prone to clogging,
- Parts and fittings not standardized,
- Limited application for non-row and non-orchard crops, and
- Chemical injection, including acid injection and chlorination, may be necessary

D Typical Applications of Micro-Irrigation

The typical applications of micro-irrigation systems include the following

- High value crops,
- Areas where water is very scarce or expensive,
- To allow more control over harvest timing, usually to make a high value market window,
- To allow cultural practices and harvesting at all times,
- To use marginal fields,
- To use marginal water, and
- To alleviate drainage problems

SECTION IV
APPLICATION AND ECONOMICS OF MICRO-IRRIGATION IN THE TADLA PERIMETER

A Economics of Micro-Irrigation in the Tadla Perimeter

The Tadla Perimeter does not fit the typical profile for widespread micro-irrigation application In normal years it receives an adequate supply of reasonably-priced surface water via the extensive canal system and the region in general is not excessively arid The topography is gentle and the water is not excessively saline High value crops may be adequately grown with other methods of irrigation

Micro-irrigation can, however make a significant contribution to the Tadla Perimeter through the production of high-value high-quality fruits vegetables and fibers Therefore, an examination of micro-irrigation economics is appropriate at this stage An abbreviated analysis of the economics of two crops, potatoes and citrus, was conducted It is recommended that a more thorough analysis be performed as information becomes available regarding equipment costs, crop yields, and water and other resource savings

Tables 1 through 3 estimate the annual profits involved with potato production using ropta, level basin, and micro-irrigation techniques These tables are based on a number of assumptions including a five year loan period during which the capital investments may be financed using an interest rate of five percent. Longer loan periods and lower interest rates would produce results more favorable to micro-irrigation The results are summarized in Table 4

Table 1

Estimated Annual Profit Calculations for Potatoes
For Selected Irrigation Techniques in the Tadla Perimeter

Ropta

Assumptions		
Annual Interest Rate	5.0%	
Investment Period	5	years
Crop	Potatoes	
Base Crop Yield	250	quintal/ha
Crop Value	100	dirhams/quintal
Base Area	250	hectares

Initial Inputs

Item	Initial Cost (Dh)	Annualized Cost (Dh)	Annualized Cost Per Hectare (Dh/ha)
None	0	0	0
	0	0	0
Capital Investment Total	0	0	0

Annual Inputs

Item	Annual Cost (Dh/ha)	
Water	610	
Irrigation Labor	400	
Other Labor (land prep , harvesting, etc.)	2,400	
Seed	6,000	
Fertilizer & Herbicides	2,900	
Farmer - Salary & Overhead	100	
Annual Subtotal	12,410	
Grand Total of Annualized Costs	12,410	(Dh/ha)
Outputs		
Crop Value	100	(Dh/q)
Base Crop Yield	250	(q/ha)
Percent Increase in Yield Due to Irrigation Method	0%	
Modified Crop Yield	250	(q/ha)
Gross Receipt	25,000	(Dh/ha)
Minus Annualized Inputs	(12,410)	(Dh/ha)
Annual Profit for Investment Period	12,590	(Dh/ha)

Table 2

Estimated Annual Profit Calculations for Potatoes
For Selected Irrigation Techniques in the Tadla Perimeter

Level Basin

Assumptions		
Annual Interest Rate	5.0%	
Investment Period	5	years
Crop	Potatoes	
Base Crop Yield	250	quintal/ha
Crop Value	100	dirhams/quintal
Base Area	250	hectares

Initial Inputs

Item	Initial Cost (Dh)	Annualized Cost (Dh)	Annualized Cost Per Hectare (Dh/ha)
Scraper	68,000	15,700	60
Laser Equipment	102,000	23,600	90
Capital Investment Total	170,000	39,300	150

Annual Inputs

Item	Annual Cost (Dh/ha)	
Scraper O&M	300	
Water	460	
Irrigation Labor	100	
Other Labor (land prep, harvesting, etc)	2,400	
Seed	6,000	
Fertilizer & Herbicides	2,900	
Farmer - Salary & Overhead	100	
Annual Subtotal	12,260	
Grand Total of Annualized Costs	**12,410**	(Dh/ha)
Outputs		
Crop Value	100	(Dh/q)
Base Crop Yield	250	(q/ha)
Percent Increase in Yield Due to Irrigation Method	20%	
Modified Crop Yield	300	(q/ha)
Gross Receipt	**30,000**	(Dh/ha)
Minus Annualized Inputs	**(12,410)**	(Dh/ha)
Annual Profit for Investment Period	**17,590**	(Dh/ha)

Assumptions	
Level basin irrigation decreases water use by	25%
Level basin irrigation increases crop yield by	20%

Table 3

Estimated Annual Profit Calculations for Potatoes
For Selected Irrigation Techniques in the Tadla Perimeter

Micro-Irrigation

Assumptions		
Annual Interest Rate	5 0%	
Investment Period	5	years
Crop	Potatoes	
Base Crop Yield	250	quintal/ha
Crop Value	100	dirhams/quintal
Base Area	250	hectares

Initial Inputs

Item	Initial Cost (Dh)	Annualized Cost (Dh)	Annualized Cost Per Hectare (Dh/ha)
Micro-Irrigation System	6,250,000	1,443,600	5,770
	0	0	0
Capital Investment Total	6,250,000	1,443,600	5,770

Annual Inputs

Item	Annual Cost (Dh/ha)	
Water	430	
Irrigation System O&M	1,200	
Other Labor (land prep , harvesting, etc)	2,400	
Seed	6,000	
Fertilizer & Herbicides	2,320	
Farmer - Salary & Overhead	100	
Annual Subtotal	12,450	
Grand Total of Annualized Costs	18,220	(Dh/ha)

Outputs		
Crop Value	100	(Dh/q)
Base Crop Yield	250	(q/ha)
Percent Increase in Yield Due to Irrigation Method	30%	
Modified Crop Yield	325	(q/ha)
Gross Receipt	32,500	(Dh/ha)
Minus Annualized Inputs	(18,200)	(Dh/ha)
Annual Profit for Investment Period	14,300	(Dh/ha)

Assumptions	
Micro-irrigation decreases water use by	30%
Micro-irrigation increases crop yield by	30%
Micro-irrigation decreases fertilizer use by	20%

Table 4
Economic comparison of three Irrigation Techniques in the Tadla Perimeter For Potatoes
(Dirhams per Hectare)

	Ropta	Level Basin	Micro-Irrigation
Initial Capital Investment	0	680	25,000
Annualized Costs	12,400	12 400	18,200
Expected Crop Value	25,000	30,000	32,500
Expected	12,600	17,600	14,300

Assumptions
Profit estimated for invesment period of five years
Interest rate of five percent.
Base crop yield of 250 q/ha
Crop value of 100 Dh/q
Level basin irrigation decreased water use by 25% and increased crop yield by 20%
Micro-irrigation dicreased water use by 30% decreased fertilizer use by 20% and increase yield by 20%
Based on an irrigated area of 250 hectares

Figures 2 through 5 highlight some of the relevant features of tables 1 trough 3 Figure 2 illustrates the high initial capital investment required by micro-irrigation (estimated at 25,000 DH/ha), while figure 4 demonstrates that the highest yields can be anticipated by using micro-irrigation systems Figure 5 demonstrates that, for the five-year period examined, the highest profits could be anticipated using level basin irrigation, not micro-irrigation It should be noted, however, that once the five-year loan period has ended the annualized loan repayments will cease to be a factor and the highest anticipated profits will be realized with micro-irrigation systems

While the analysis is fairly sensitive to interest rates and loan periods, it should also be noted that obtaining the loan required for a micro-irrigation capital investment could be an insurmountable task for a small farmer Perhaps some sort of cooperative structure would have to be implemented regarding the financing and use of micro-irrigation equipment.

Tables 5 and 6 and Figures through 9 provide a similar analysis for a surface and micro-irrigation applied to mature citrus The results are summarized in table 7

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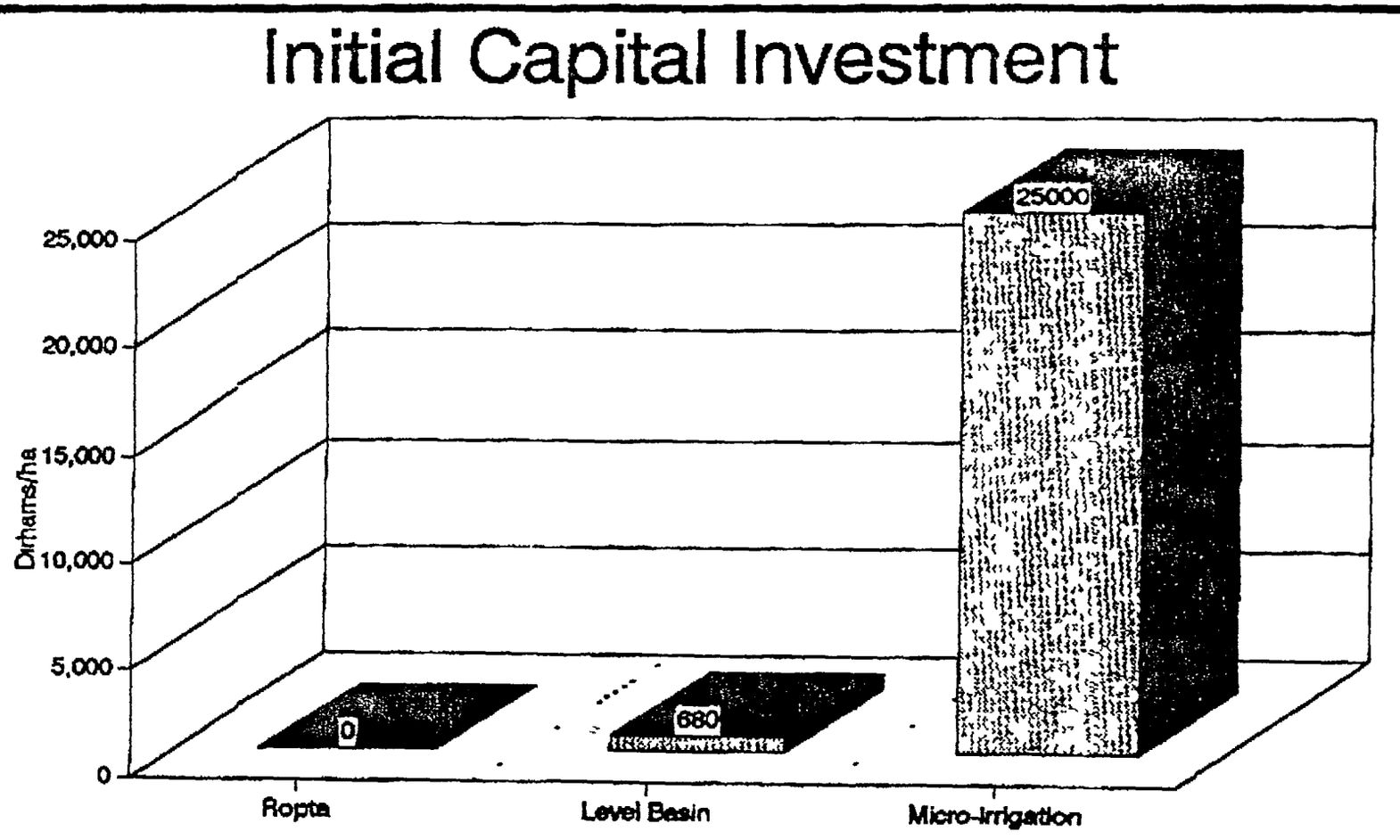
Figure 2
Initial Capital Investment for Selected Irrigation Techniques
For Potatoes in the Tadla Perimeter



Assumptions.
Base area of 250 hectares irrigated.

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Figure 3
Annualized Costs for Selected Irrigation Techniques
For Potatoes in the Tadla Perimeter

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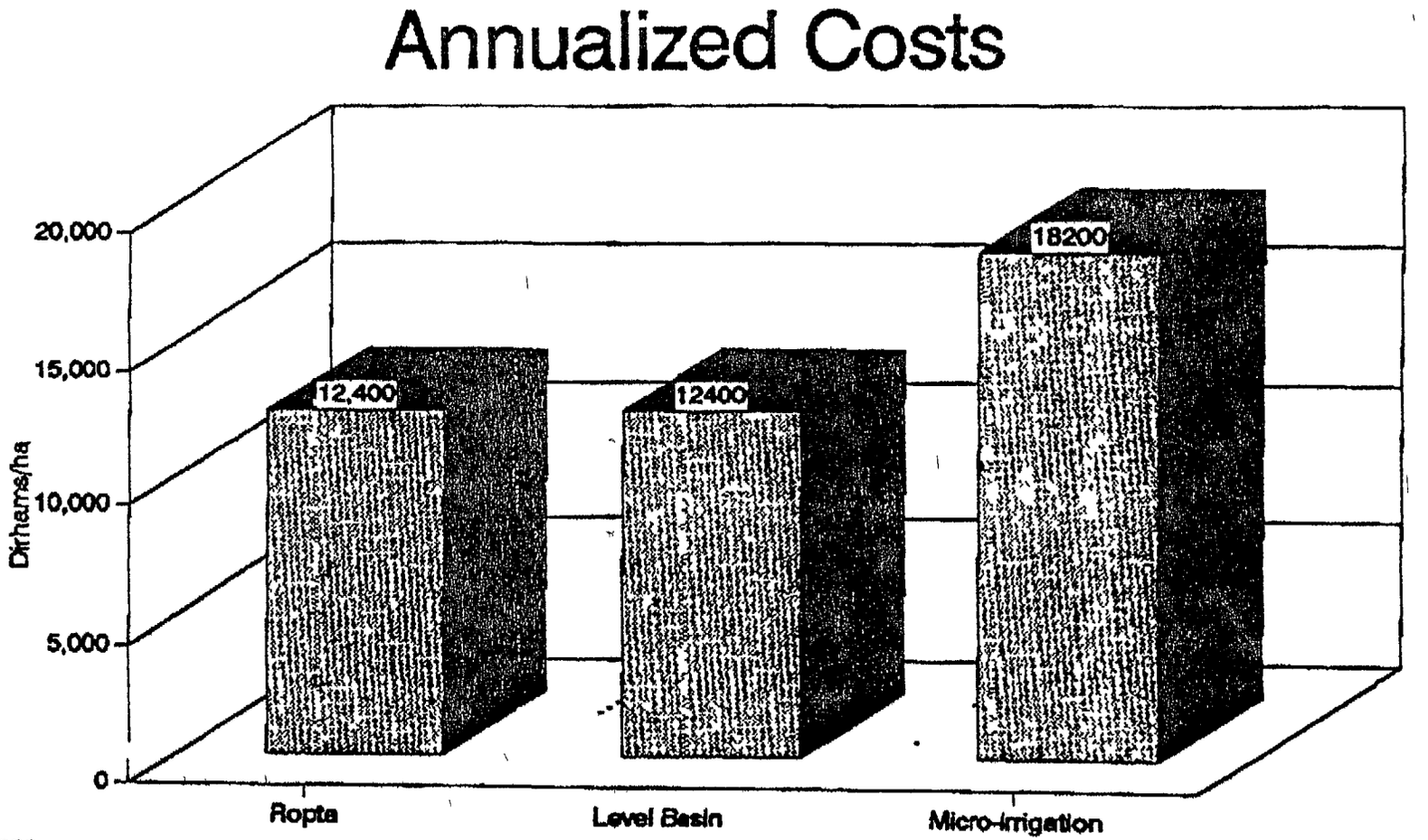

Assumptions.
Base area of 250 hectares irrigated.
Annual interest rate is 5%.
Investment period is 5 years.
Micro-irrigation decreases water use by 30% and fertilizer by 20%.

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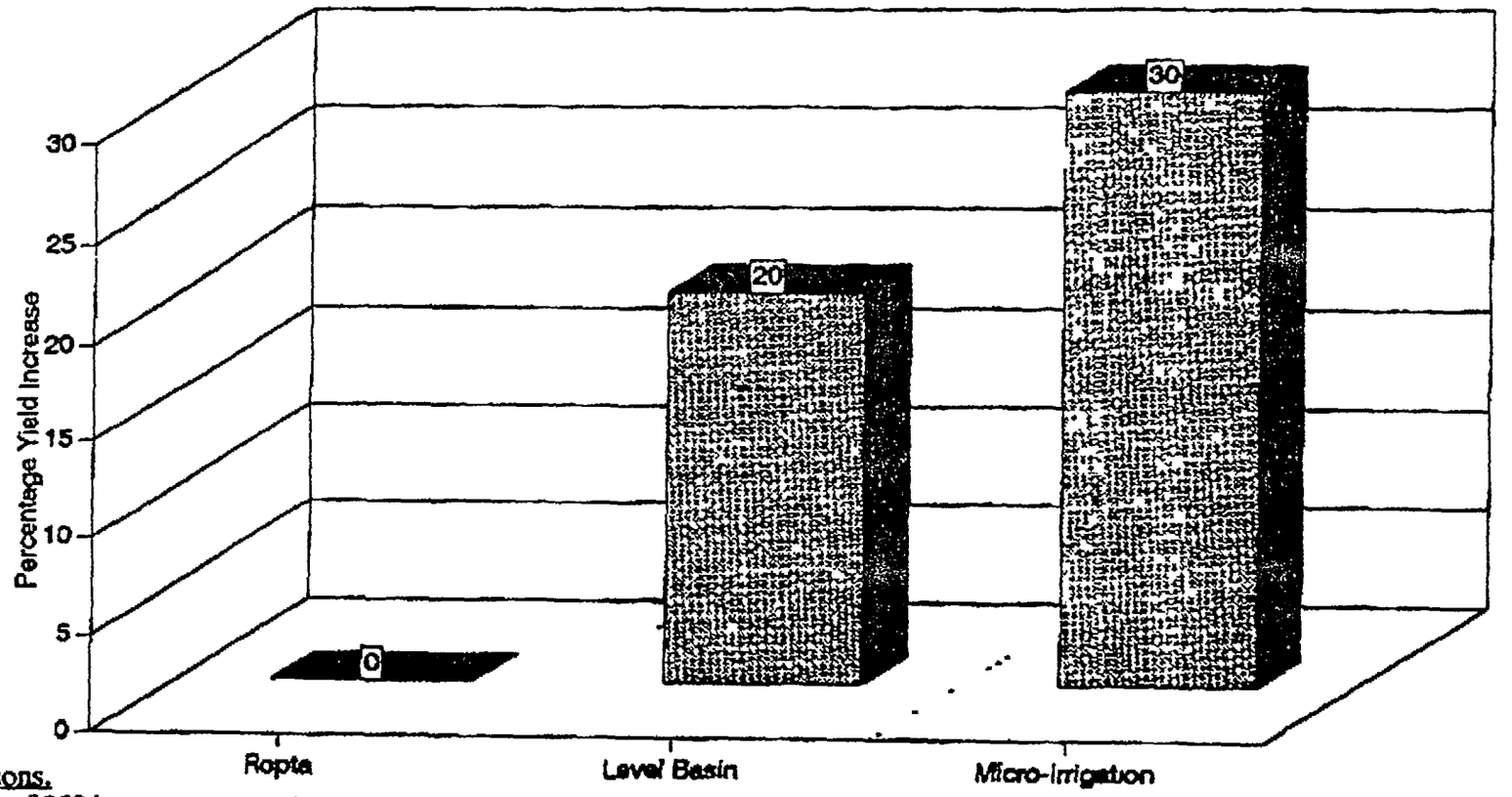
Figure 4
Increase in Crop Yields for Selected Irrigation Techniques
For Potatoes in the Tadla Perimeter

Anticipated Increase in Crop Yields



Assumptions.
Base area of 250 hectares irrigated
Annual interest rate is 5%.
Investment period is 5 years.
Micro-irrigation decreases water use by 30% and fertilizer by 20%.
Level basin increases crop yield 20%.

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Figure 5
Annual Profit for Selected Irrigation Techniques
For Potatoes in the Tadla Perimeter

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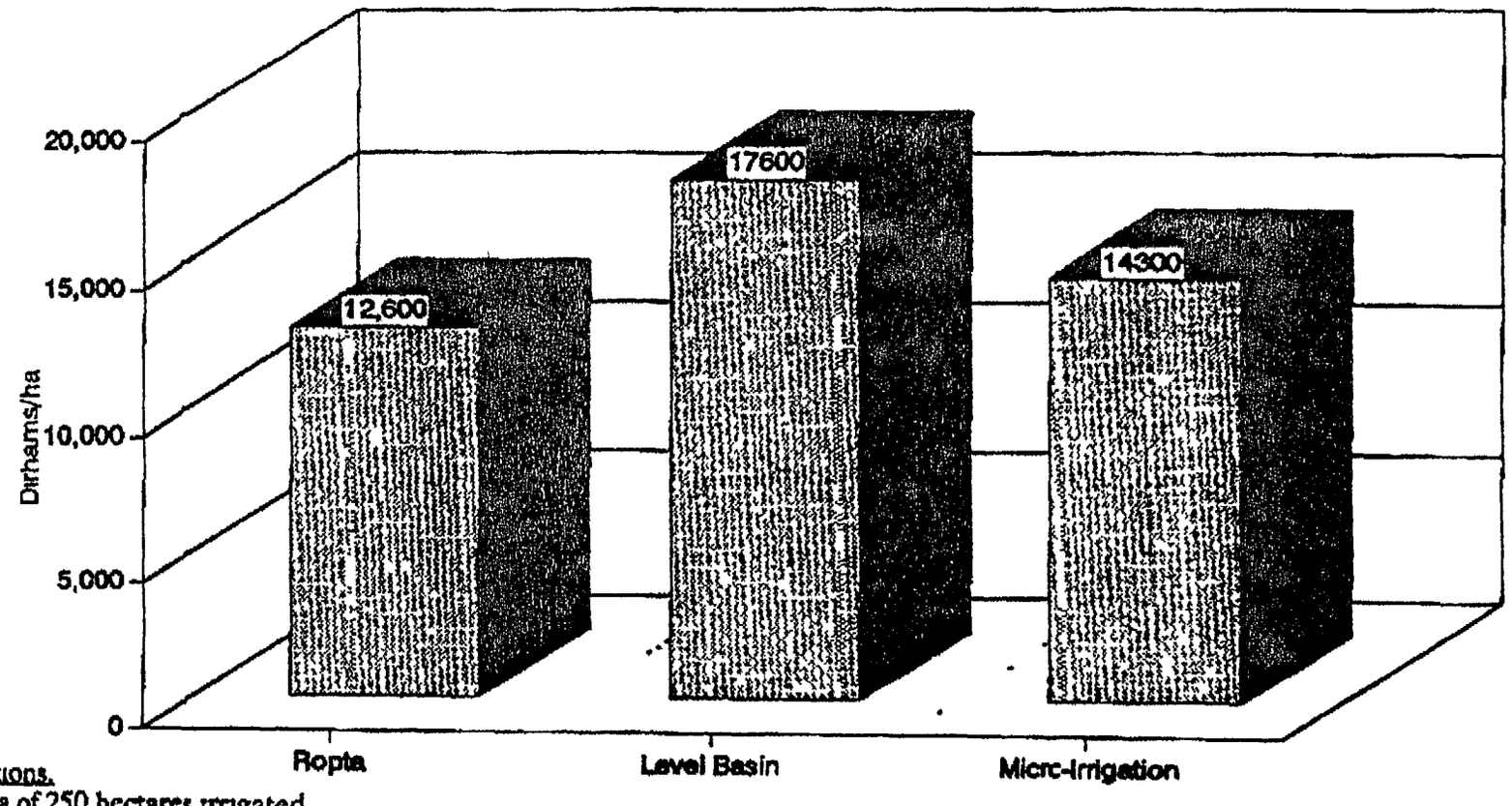

Assumptions.
Base area of 250 hectares irrigated
Annual interest rate is 5%, investment period is 5 years
Level basin decreases water use by 25% and increases crop yield by 20%.
Micro-irrigation decreases water use by 30% and fertilizer by 20%
Micro-irrigation increases yield by 30%

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Table 5

Estimated Annual Profit Calculations for Mature Citrus
For Selected Irrigation Techniques in the Tadla Perimeter

Surface

Assumptions		
Annual Interest Rate	5 0%	
Investment Period	5	years
Crop	Mature Citrus	
Base Crop Yield	200	quintal/ha
Crop Value	120	dirhams/quintal
Base Area	30	hectares

Initial Inputs

Item	Initial Cost (Dh)	Annualized Cost (Dh)	Annualized Cost Per Hectare (Dh/ha)
None	0	0	0
	0	0	0
Capital Investment Total	0	0	0

Annual Inputs

Item	Annual Cost (Dh/ha)	
Water	1,470	
Irrigation Labor	720	
Other Labor (land prep , harvesting, etc)	1,030	
Annualized Tree Cost	400	
Fertilizer & Herbicides	2,900	
Farmer - Salary & Overhead	100	
Annual Subtotal	6,620	
Grand Total of Annualized Costs	6,620	(Dh/ha)
Outputs		
Crop Value	120	(Dh/q)
Base Crop Yield	200	(q/ha)
Percent Increase in Yield Due to Irrigation Method	0%	
Modified Crop Yield	200	(q/ha)
Gross Receipt	24,000	(Dh/ha)
Minus Annualized Inputs	(6,600)	(Dh/ha)
Annual Profit for Investment Period	17,400	(Dh/ha)

Table 6

Estimated Annual Profit Calculations for Mature Citrus
For Selected Irrigation Techniques in the Tadla Perimeter

Micro-Irrigation

Assumptions		
Annual Interest Rate	5 0%	
Investment Period	5	years
Crop	Mature Citrus	
Base Crop Yield	200	quintal/ha
Crop Value	120	dirhams/quintal
Base Area	30	hectares

Initial Inputs Item	Initial Cost (Dh)	Annualized Cost (Dh)	Annualized Cost Per Hectare (Dh/ha)
Micro-Irrigation System	750,000	173,200	5,770
	0	0	0
Capital Investment Total	750,000	173,200	5,770

Annual Inputs Item	Annual Cost (Dh/ha)	
Water	1,030	
Irrigation System O&M	1,200	
Other Labor (land prep, harvesting, etc)	1,030	
Annualized Tree Cost	400	
Fertilizer & Herbicides	2,320	
Farmer - Salary & Overhead	100	
Annual Subtotal	6,080	
Grand Total of Annualized Costs	11,850	(Dh/ha)
Outputs		
Crop Value	120	(Dh/q)
Base Crop Yield	200	(q/ha)
Percent Increase in Yield Due to Irrigation Method	18%	(0% for 2 yr, 30% for 3 yr)
Modified Crop Yield	236	(q/ha)
Gross Receipt	28,300	(Dh/ha)
Minus Annualized Inputs	(11,900)	(Dh/ha)
Annual Profit for Investment Period	16,400	(Dh/ha)

Assumptions		
Micro-irrigation decreases water use by	30%	
Micro-irrigation increases crop yield by	30%	After first two years
Micro-irrigation decreases fertilizer use by.	20%	

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Figure 6
Initial Capital Investment for Selected Irrigation Techniques
For Mature Citrus in the Tadla Perimeter

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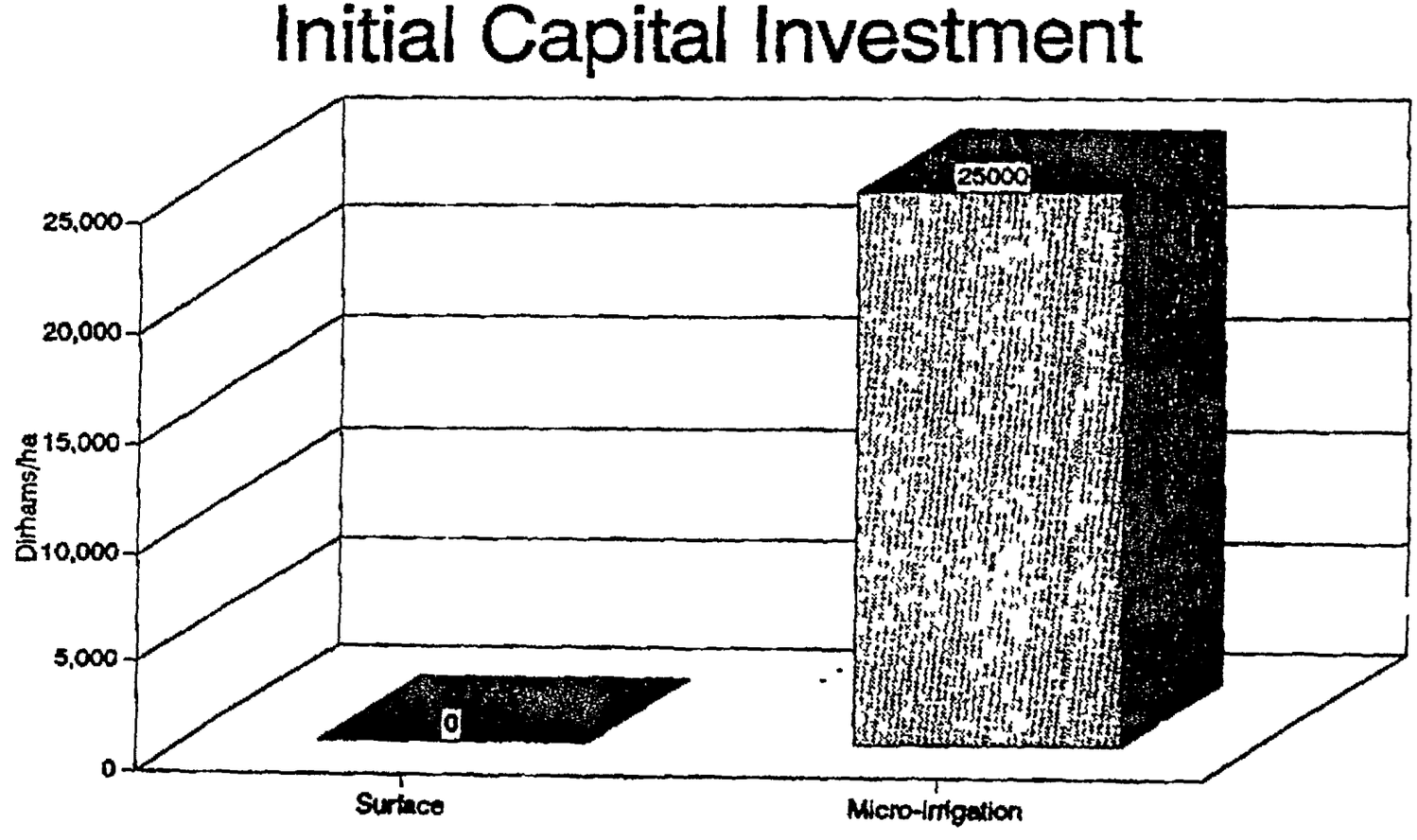

Assumptions.
Base area of 250 hectares irrigated.

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Figure 7
Annualized Costs for Selected Irrigation Techniques
For Potatoes in the Tadla Perimeter

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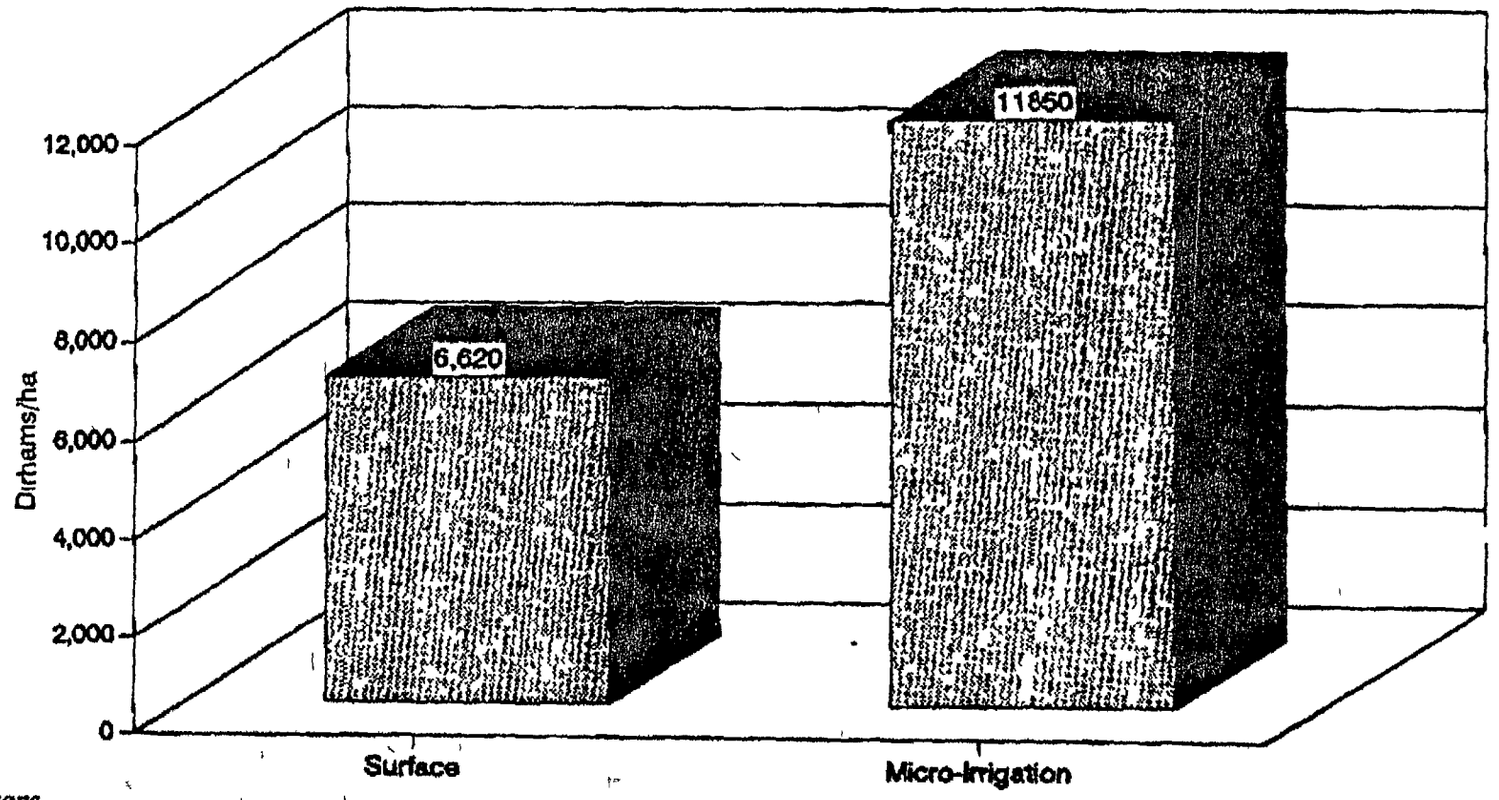

Assumptions.
Base area of 250 hectares irrigated.
Annual interest rate is 5%.
Investment period is 5 years
Micro-irrigation decreases water use by 30% and fertilizer by 20%

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Figure 8
Increase in Crop Yields for Selected Irrigation Techniques
For Mature Citrus in the Tadla Perimeter

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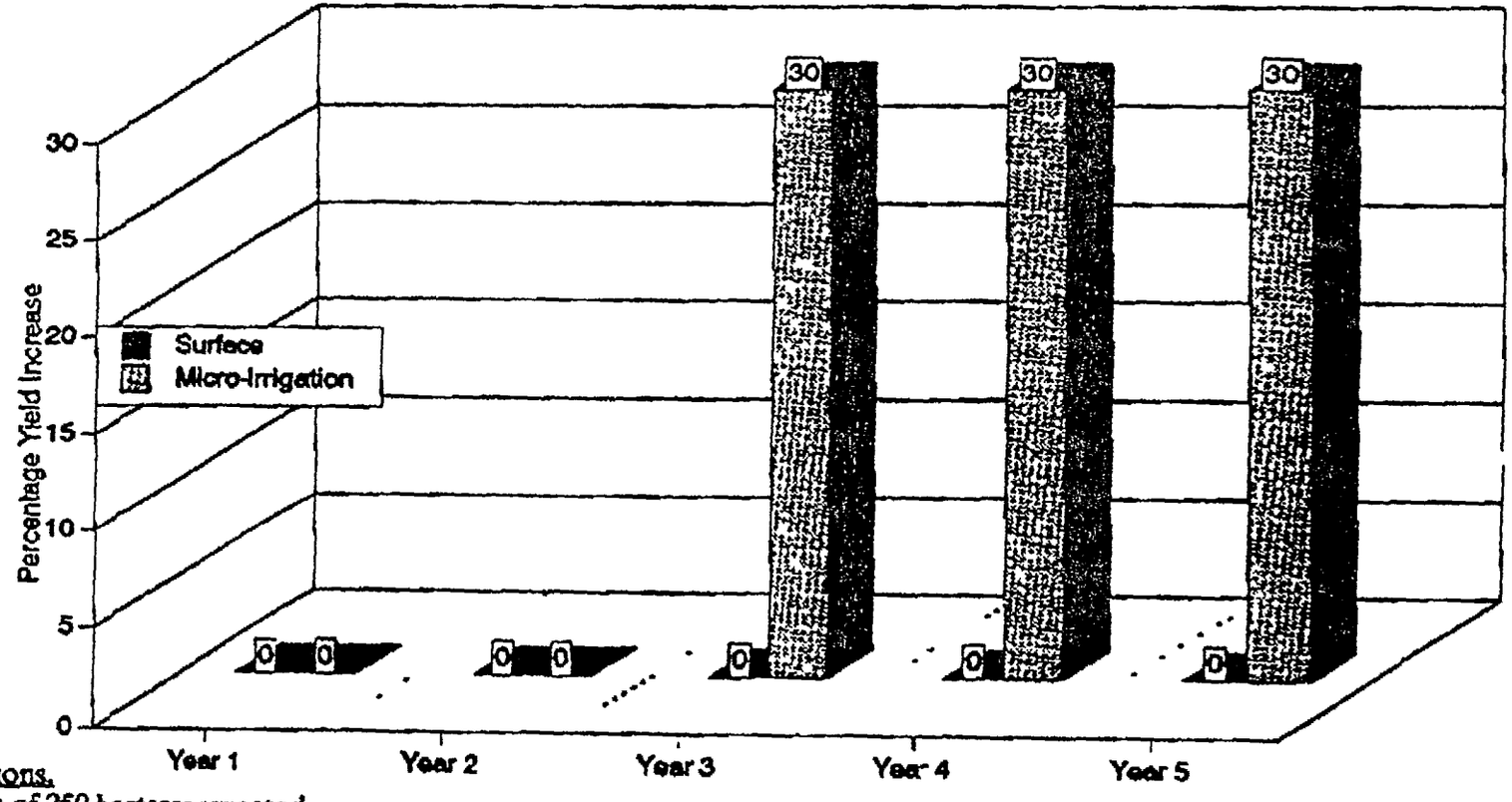

Assumptions.
Base area of 250 hectares irrigated.
Annual interest rate is 5%
Investment period is 5 years.
Micro-irrigation decreases water use by 30% and fertilizer by 20%.
Micro-irrigation increases crop yield 30% after two years of no increase.

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Figure 9
Annual Profit for Selected Irrigation Techniques
For Mature Citrus in the Tadla Perimeter

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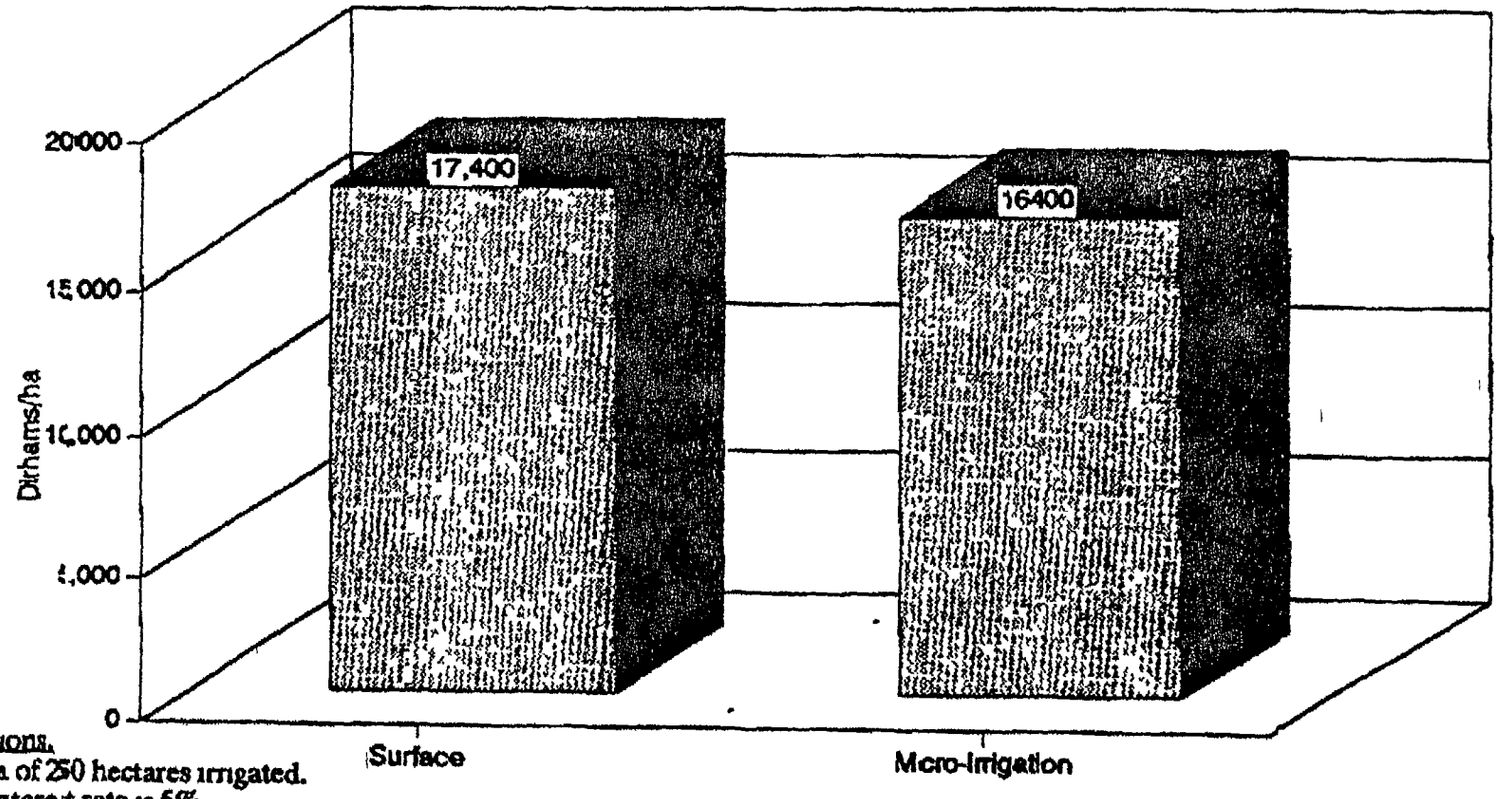
Annual Profit for Investment Period



Assumptions.
Base area of 250 hectares irrigated.
Annual interest rate is 5%
Investment period is 5 years
Micro-irrigation decreases water use by 30% and fertilizer by 20%.
Micro-irrigation increases yield by 30% after two years
Note, after investment period micro-irrigation profit increases to 22,000 Dh/ha.

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Table 7

Economic Comparison of Two Irrigation Techniques
In the Tadla Perimeter
For Mature Citrus

(Dirhams per hectare)

	Surface	Micro Irrigation
Initial Capital Investment	0	25 000
Annualized Costs	6,600	11,900
Expected Crop Value	24,000	28,300
Expected Profits	17,400	16,400

Assumptions

Profit estimated for investment period of five years
Interest rate of five percent
Bae crop yield of 200 q/ha
Crop value of 120 Dh/q

For micro-irrigation the crop yields did not change for the first two years but increased 30% thereafter
Micro-irrigation decreased water use by 30% and decreased fertilizer use by 20%
Level basin irrigation techniques were assumed to be currently not applicable to citrus

It should be noted that, for the first five years, more profit per hectare can be realized with surface than with micro-irrigation techniques However, once the micro-irrigation initial capital investment loan is retired and the increase in productivity is realized the profit per hectare increases to 22 200 dh which is a substantial improvement over the 17 400 dh per hectare realized with conventional surface methods

The foregoing analyses suggest that, if sufficient capital is available and if the systems are well managed, micro-irrigation can be used in the Tadla perimeter to increase long-term profits on certain high-value crops However, the foregoing analyses also support the need for thorough economic analyses on a farm-by-farm basis prior to the purchase of a micro-irrigation system In particular the incremental costs and benefits between level basin and micro-irrigation should be examined

B Comparison of Micro-Irrigation to Selected Other Irrigation Techniques

The following table enumerizes some of the major elements of selected irrigation techniques in the Tadla perimeter

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Table 8

Comparison of Selected Irrigation Methods in the Tadla Perimeter

	Ropta	Level Basin	Micro-irrigation
Current use in Tadla Perimeter	Predominant	Experimental	Experimental and minor production
Water savings potent.	Minimal	Excellent	Excellent
Crop yield potential	Average	20% increase	30% increase
Initial Capital Costs	None	680 dh/ ha	25,000 dh /ha
Operation and Maint.	Simple	Moderate	Complex

The forgoing table and the economic analysis in the previous section have been presented to provide some insight into the relative merits of different irrigation techniques Although micro-irrigation has the potential to save the most water and produce the best crop yields, it is not appropriate for every farm The following section elaborates on some of the major concerns regarding micro-irrigation in the Tadla Perimeter

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SECTION V
IDENTIFICATION OF MAJOR IMPEDIMENTS AND RECOMMENDATIONS AND COMMENTS ON EXISTING SYSTEMS.

A Major Impediments to Micro-Irrigation Success in the Tadla Perimeter

At the present time there appears to be sufficient access to high-quality equipment and correct design and installation procedures in the Tadla perimeter With the large amount of interest in micro-irrigation in the Tadla Perimeter, it is important to keep the quality of equipment, design, and installation high But, while these factors are important they alone do not insure micro-irrigation success The following are three additional major identified impediments to the success of micro-irrigation in the Tadla Perimeter

- **Large initial capital investment** - Micro-irrigation requires in contrast to gravity forms of irrigation, an enormous amount of initial capital investment Quoted prices ranged from 15,000 to 30,000 dh/ha While there maybe a special line of credit available for the purchase of micro-irrigation systems it still takes a certain amount of foresight and courage to enter into such a debt

There is a definite economy of scale with micro-irrigation systems All systems need a pump, filter and fertilizer injector in addition to the PVC pipes and driplines In other words, large systems tend to cost less on a per hectare basis than small systems It may be possible to organize collectives to share in the cost of some elements of the system in order to realize savings for all

- **Transfer of technology to on the farm** - Micro-irrigation system operations are unlike any other form of irrigation They operate with much less margin for error and require mastery of new concepts such as fertilizer and acid injection They also require a rigorous maintenance regime including cleaning the filters and purging the driplines It is imperative that the farmer thoroughly understand and be comfortable with these new concepts While all the dealers interviewed indicated that they supplied support to the farmers and one dealer actually trains on -farm personnel, the depth and effectiveness of these services were not verified

- **Ability to recoup investment** - Because of the high initial investment, the farmer must have some assurance of being able to realize enough profit with the micro-irrigation system to make the venture worthwhile Typically this involves market research and possible securing of future markets of high-value crops It is important to identify high-value crops and markets in advance

In order to overcome these impediments, and assure continuing quality in equipment, design, and installation it would be helpful to establish expertise within ORMVAT to provide

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impartial (i e not motivated by the profit of equipment sales) advice to farmers The center for Irrigation Techniques (ORMVAT) provides an example or one way this could be accomplished This organization maintains on going demonstrations of micro-irrigation techniques, provides design services, and will oversee system installation, but does not sell equipment or sollicite business For the design alone the charge to the farmer is one percent of the total equipment value For overseeing installation the charge is three percent of total equipment value This sort of impartial advice could be an invaluable service It is recommended that ORMVAT consider performing this service for Tadla Perimeter farmers, and extending it to include advice on system maintenance

It is also recommended for ORMVAT to take a more pro-active approach in farmer education on micro-irrigation issues Several methods of accomplishing this would be to develop micro irrigation "fact sheets" and newsletters for direct distribution to farmers and the hosting of the micro-irrigation information fairs The newsletters and fact sheets could cover specific issues such as salinity management, crop water requirements, equipment selection and system maintenance The information fairs could be annual events featuring equipment supplier display booths and talks on current micro-irrigation issues

B Existing Micro-Irrigation Systems in the Tadla Perimeter

Approximately 1,000 ha in the Tadla perimeter are currently equipped with some variety of micro-irrigation system Table 9 lists the known micro-irrigation systems by owner, size crop, and type of micro-irrigation system

Between February 27 and March 4, 1996, micro-irrigation systems on five farms in the Tadla perimeter were toured In addition, meetings were held with five active micro-irrigation dealers and three farms were toured near marrakech

In general, the micro-irrigation systems seemed to be operational and their managers seemed to be satisfied with them Hydraulically, the systems were sound and operating without excessive pressure losses

The oldest system was five years old and had undergone substantial rehabilitation The newer systems (two or fewer years old) were functional without substantial modifications

Figure 10, illustrates a typical micro-irrigation system in the Tadla Perimeter Such a system would use a submersible pump to pressurize water from a well Immediately downstream of the pump, a screen or disk filter functions as the sole filtration unit for the system A pressure relief valve and air vent would be found on the filter station Immediately downstream of the filter would be a chemical injection device Both injection pumps and venture-type injectors were observed (although not on the same installation)

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IRRIGATION LOCALISEE

Table 9

CDA	Agriculteur	Superficies Equipées	Cultures	SYSTEME	Observation
503	—	4,5 ha	Agrumes	Ajutage	Zone bour
520	Oudghiri M	17 ha	Pommiers	Goutte à goutte	
		7 ha	Peckers	Goutte à goutte	
520	Domaine	4 ha	Pommiers	Microjet	
	Hassania	4 ha	Peckers	Microjet	
		39 ha	Agrumes	Microjet	
522	Voinier	16 ha	Rosacees	Goutte à goutte	
	SEKKAT	143 ha	Agrumes	Goutte à goutte	
	Manchia	15 ha	Vervene	Goutte à goutte	
523	SATA	51,5 ha	Rosacees	Microjet	
		150 ha	Agrumes	Goutte à goutte	
		10 ha	Olivier	Goutte à goutte	
523	SMEA	94 ha	Agrumes	Goutte à goutte	
		1,7 ha	Olivier	Goutte à goutte	
523	Mounir D.	10 ha	Agrumes	Microjet	
524	—	7,81 ha	Rosacées	Goutte à goutte	
526	Lemzami B.	5 ha	Agrumes	Goutte à goutte	
527	Sefiani M.	21 ha	Agrumes		
		18 ha	Rosacées		
	Dar cherqui	15,5 ha	Rosacées	Goutte à goutte	
528	Lahmam M.	13 ha	Agrumes	Goutte à goutte	
530	Bennani Smirs	107,4 ha	Agrumes	Goutte à goutte	
	(Domaine Hbabiss)	21 ha	Rosacées	Goutte à goutte	
	Belhcen L.	41 ha	Agrumes	Goutte à goutte	
	SEKKAT	20 ha	Agrumes	Goutte à goutte	
	Kaitouni	40 ha	Maraichage	Goutte à goutte	
	Thami Amar	18,5 ha	Agrume	Goutte à goutte	
		10 ha	Rosacées	Goutte à goutte	
	Lahmam K	10,8 ha	Agrumes	Goutte à goutte	

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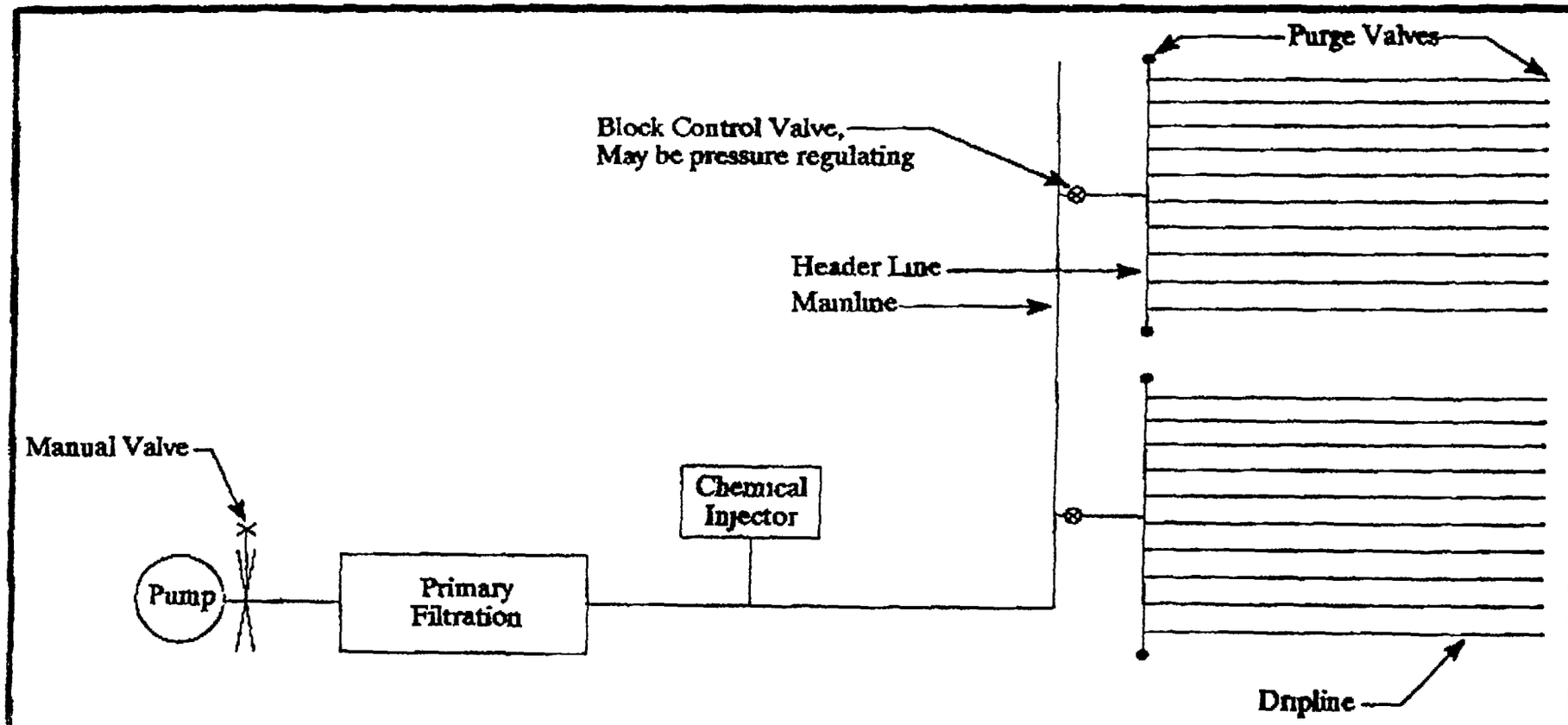
Figure 10
Typical Micro-Irrigation System in the Tadla Perimeter Schematic



As Required:
- Air Vents
- Pressure Relief Valves

TYPTAD WPG

The filter station would discharge into a PVC mainline pipe, wish conveyed the water to the operating blocks The block control valves observed were both manual and hydraulically actuated and were uniformly of high quality

The PVC header line would be linked to the driplines by means of drilled holes and grometted connections Most of the observed driplines either had katif emitters prepunched into them or an-in line emitter extruded into them Micro-sprinklers were observed on citrus The ends of all of the observed driplines were closed with standard "figure8" fittings

Several general impressions of the systems are summarized below

- **Filtration** - Good filtration is an absolute necessity for successful micro-irrigation Typically a system in the Tadla Perimeter will only have one screen filter, situated upstream of the chemical injection point This practice is not advisable The filtration systems could be improved in the following ways

1 The primary filtration should be located downstream of the chemical injection point in order to filter out any precipitates which may form as the fertilizers react with the water

2 Secondary filtration units should be added at the head of each manifold. These could be small screen filters, which would provide protection for the emitters and micro-sprinklers in the event of a mainline break or primary filter failure When compared to the cost of replacing all of the emitters or micro-sprinklers, these secondary filters are inexpensive insurance

3 Screens alone do not provide safe, adequate, long-term filtration If a hole develops in the screen the filter is immediately rendered useless Unfortunately, unless the pressure differential across the filter is being monitored, this development could be unnoticed until the emitters are contaminated Unless there are assurances of continuously clean water disk or media filters should be used as the primary filtration device

- **Pressure Regulation** - Pressure regulation assures that the emission devices and fittings are operating within their specified ranges Pressure regulators were not observed on any of the installation visited The SATA farm and the Kaitouni farm both had a Bernard pressure regulating valve as the block control valve, but not independent pressure regulators The system seem to run at relatively high pressures (1 to 4,5 bars) Manufacturer's recommendations typically run from 1 to 2 5 bars The SATA farm had problems with barbed fittings and micro-sprinklers popping out of the tubing Increased pressure regulation would also allow water distribution to be more precisely controlled and energy cost savings to be realized The recommendations are as follows

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1 Either the system pressure must be reduced or fittings and emission devices which can accommodate the higher pressures must be utilized System pressures could be reduced with pressure regulators at each manifold valve Pressure reducing valves as block control valves are also an option, although they cannot react quickly enough to protect against sudden pressure surges

Conversely, if the system pressures were not reduced, the systems would still be functional if different fittings were used Glued and / or threaded (both parts of the fitting need to be threaded) fittings would be appropriate for higher pressures Barbed threaded (on one side only), and grommetted fittings are bound to fail at higher pressures

- **Purge Valves** - Along with filtration purge valves help to keep the system clean and the emission devices functioning properly All systems toured had purge valves on the ends of the header lines, but none were observed at the ends of the mainlines The purge valves generally consisted of a threaded male cap which, when removed, would direct the purged water directly upwards Also, in general the purge valves were at least one pipe size smaller than the served header line The recommendations are as follows

1 The purge valves should be the same size as the served manifold in order to ensure good pressure at the line and adequate velocities at the head of the line for purging For this reason also, it is recommended that the manifolds not be allowed to decrease in size more than one or, at the absolute most, two pipe sizes

2 Although the threaded caps serve as adequate purge valves butterfly or ball valves would provide more ease of use and a longer service life

3 The purge valves should be located so as to direct the purged water to a convenient location For example a pipe could be extended under a road so as to direct the purge water into a ditch instead of on to the road

4 Purge valves should also be installed at the end(s) of the mainline(s)

- **Maintenance** - Maintenance is important for all kinds of irrigation systems, and is especially essential to continued operation of micro-irrigation systems All the toured systems employed some sort of maintenance schedule The simplest involved purging the lines and cleaning the filter upon system start-up at the beginning of the growing season The SATA farm had the most sophisticated It involved a purging schedule for the driplines, header lines, and filter, and also had an acid injection schedule Recommendations are as follows

1 Regular maintenance schedules should be developed which would identify routing on-going activities performance indicators and remedies for system non-performance As a

minimum, such a program would involve the following

- Purging mainlines,
- Purging header lines,
- Purging driplines,
- Acid injection,
- Backwashing filters,
- Cleaning filters elements;
- Visual inspection of emission device discharge,
- Monitoring system flow,
- Monitoring pressure drop across filters,
- Monitoring pressure at header lines
- Provision for flushing salts from the soil, and
- Chlorination of surface water

- **Isolation Valves, Union, Victaulic connections, Etc** - Although not absolutely necessary, there are a number of manual valves and connections which make system components much easier to service These include manual gate, ball, or butterfly valves upstream of block control valves, union or Victaulic connections for valves, filters, pressure regulators, and any other component which may have to be periodically removed for servicing

- **PVC Pipe Installation** - No direct installation process was observed However, from discussions with system managers it was ascertained that PVC pipe and fittings were connected by means of solvent weld joints using glue only It is recommended that appropriate primer be used in conjunction with the solvent weld glue, especially on pipe sizes larger than 4 cm in diameter This will ensure longer-lasting glue joints

There was also some dissatisfaction with the variable quality of the PVC and PE available in Morocco although these difficulties were not observed first hand In order to provide other recommendations for installation practices, field installations would need to be observed first-hand.

- **Ajutage** - This form of irrigation was observed primarily in the area around Marrakech The emission devices are brass nozzles, approximately 1/2 cm in diameter, which have been punched into the tubing This represents a minimal amount of flow regulation and the flows at the beginning of the tubing will be much higher than the flows at the end However, because of their larger emission device orifice size, ajutage systems require less filtration than drip or micro-sprinklers and are therefore easier to manage Ajutage system costs (20,000 dh/ha) are comparable to micro-irrigation system costs (15,000 to 30,000 dh/ha), but deliver much poorer results in terms of water savings therefore, ajutage is not

recommended for wide applications in the Tadla Perimeter

- Micro-sprinklers - Several citrus orchards with micro-sprinkler installations were observed in the Tadla Perimeter Citrus Orchards with drip irrigation were also observed Micro-Sprinklers provide a larger wetted area than drip irrigation which is especially important in sandy soils, and have the added benefit of providing some measure of frost control However micro-sprinklers have the disadvantages of sensitivity to wind, difficulty of keeping vertical more water loss to evaporation, and the wetting of low-hanging leaves and fruit

The Tadla perimeter has predominantly "heavy" and not sandy soils and may not need the added frost protection benefit Drip irrigation, with properly spaced emitters and driplines should be adequate for most Tadla citrus applications Each orchard, however, should be reviewed on an individual basis

- **Conversion of Mature Orchards** - The conversion of orchards which have been raised on surface irrigation to micro-irrigation has been observed in the Tadla perimeter While possible, it should be noted that micro-irrigation will change the root structure of the plants involved and a short-term los of productivity will likeky be observed These systems must be carefully designed and operated with these special concerns in mind

C Brief Overview of Existing Suppliers

During discussions with Moroccan micro-irrigation suppliers, it became evident that a great deal of interest exists for selling micro-irrigation equipment in the Tadla Perimeter Several dealers are actively pursuing this market and one even has local representation in Fquih Ben Saleh A list of the suppliers contacted may be found in Appendix C

All dealers visited have access to qualify equipment and provided assurances of on-going technical support Most of the dealers carried a mix of equipment from France Spain Italy Israel, the United States and Morocco All the polythlene tubing was manufactured in Morocco

It is crucial to the success of micro-irrigation in the Tadla Perimeter that design, equipment, installations, maintenance, and on-going dealer support are of the highest quality In the U S A there are many unfortunate examples of over enthusiastic dealers who overstate the advantages of micro-irrigation to farmers with the sole intent of selling their equipment without regard to the appropriateness or success of the system Farmers have been induced to purchase inferior equipment and install large and unmanageable areas

While good quality equipment is certainly available to Tadla farmers it is important that they have the resources available with which to make intelligent decisions regarding micro-irrigation systems

SECTION VI
RECOMMENDATIONS FOR FUTURE ACTIONS

Education of Appropriate Personnel

A series of seminars for the appropriate ORMVAT personnel should be conducted The seminars will provide an overview of micro-irrigation, principals of design, principals of equipment selection, maintenance procedures, and installation procedures During the design seminar, for example, ORMVAT personnel will learn how to select the appropriate emitter and accompanying filtration based on the crop grown, climate, water source, topography, field geometry, economics, and hydraulics

Draft seminar outlines for the overview of micro-irrigation and design are included in Appendix A and Appendix B

The purpose of the seminars is to develop a core of qualified people who can assist the farmer in micro-irrigation issues, especially the issues identified as impediments to the successful development of micro-irrigation in the Tadla Perimeter

ANNEX .A

Micro-Irrigation Seminar Outline

Overview

I Definition

Micro-irrigation involves the precision delivery of water directly to the plants, usually at low flows and low pressures

II Purpose

To produce high quality crops while conserving resources, primarily water

III Applications

- High value crops
- Areas where water is very scarce
- To push the crop to make a high value market window
- To allow cultural practices and harvesting at all times
- To use marginal fields
- To use marginal water
- To alleviate drainage problems

IV Benefits of Micro-Irrigation

- Increased yields
- Improved crop quality
- Less water use, better water penetration
- Less fertilizer use
- Lower energy costs (compared to sprinklers)
- Less labor cost
- Less herbicide use
- Less likelihood of disease
- More efficient harvesting
- Ability to irrigated on slopes and uneven terrain
- Ability to use more saline water
- Decreased drainage problems

V Important Considerations

- High initial capital cost
- Increased sophistication of technology
- Irrigation management very different than surface or sprinkler irrigation management
- Less margin for error in amounts and timing of water applied
- Emission orifices very small and prone to clogging
- Parts and fittings not standardized
- Chemical injection, including acid injection, may be necessary

VI Economics

- Pay-back period
- Example of economics of a crop using
  - Conventional irrigation
  - Micro-irrigation
  - Level basin irrigation

IV Introduction to Micro-Irrigation Systems

Necessary components

- Emission devices
- Tubing (PE)
- Pipe (PVC)
  - Purge valves
  - On driplines
  - On lateral lines
  - On mainlines
- Fittings
  - PE fittings
  - PVC fittings
  - Fittings to get from PVC to PE
- Control valves
  - Manual
  - Hydraulic
  - Electric
- Filters
  - Primary
  - Secondary
- Pressure regulation
- Pressure measuring devices
- Fertilizer injection equipment
  - Pump
- Non-essential equipment
  - Flowmeters

ANNEX .B

Micro-Irrigation Seminar Outline

Design

I Information Needed

- Crop
- Location (Climate)
- Highest probable evapotranspiration (E T) rate
- Soil type
- Source of water
- Quality of water
- Scaled drawing
- Topography (slopes)
- Duration of system (number of seasons)
- Any special cultural concerns
- Any existing equipment to be used
- Any other constraints
- Sophistication of farmer

II Brief Overview of System Components

- Emission devices
- Polyethelyne tubing (PE)
- Poly vinyl chloride pipe (PVC)
- Fittings
- Purge valves
- Control valves
- Isolation valves
- Pressure regulating devices
- Filters
- Chemical injection equipment
- Pump
- Air vents
- Non-essential items (flowmeters, controllers, etc)

III Determine Crop Water Requirement

- Determine maximum daily crop water requirement
- Determine Length of Operation During Peak Water Use

IV Emission Device Selection

- Categories of emission devices

- Emission device selection considerations
  - General type of crop
  - Duration of system
  - Terrain
  - Length of run
  - Operating pressure
  - Water quality
  - Local experience
  - Manufacturer and dealer recommendations
  - Other considerations

- Emission Spacing Considerations

  - Soil type
  - Plant spacing
  - Local experience
  - Manufacturer's recommendations

V Determine Block Size

- Maximum length of dripline run
- Field geometry
- Flow in average dripline
- Total flow in block
- Number of blocks to operate simultaneously
- Safety factor

VI Header Line Hydraulics

- Header line sizing
- Pipe downsizing considerations
- Purge valve size considerations

VII Block Control Point Hydraulics

- Valve pressure loss
- Filter pressure loss
- Fittings
- Safety factor

VIII Mainline Hydraulics

- Mainline sizing

- Pipe downsizing considerations
- Purge valve size considerations

IX Filter Station Hydraulics

- Manufacturer's charts for
  - Valve(s)
  - Chemical injector (s)
  - Filter(s)
  - Flowmeter
  - Fittings
  - Other equipment
  - Safety factor

X Required Flow and Pressure at Pump

- Determine required pressure at pump discharge
- Determine required pump flow

ANNEXE C

List of suppliers Contacted			
Name of Firm	**Contact**	**Place**	**Phone Number**
CMGP	Youssef Moamah Administrateur	Casablanca	30 25 35
Irri-Sera	Difa Abdelhadi Responsable Technico-Commercial	Casablanca	40 20 30
TECHNOV	Hakaooui Salah Ingenieur Electromecanicien Chef du Service Technique	Casablanca	60 05 55
B & Z	Husni Zeino Mahmalat, Directeur General	Rabat	77 12 22
FIF Control	Albert Sebag, Ingenieur Agronome, Service Technico Commercial	Casablanca	30 49 39
Atlas Irrigation	Omar Aitlhou Directeur Technique	Marrakech	30 05 99