INFLUENCE OF PHREATIC DEPTH AND SOIL SALINITY ON CROP YIELD

CASE STUDY: TERTIARY CANAL CHIVILCOY MENDOZA -ARGENTINA

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1-INTRODUCTION

Those areas developed by means of surface irrigation seldom reach an efficiency higher than 60%, which indicates that, at best, 40% of the irrigation water is not used by the crops. The water leaks in subsurface manner in those places with impermeable layers, causing problems of phreatic level rising and bringing about a dicrease in the volume of air in the soil and an increase in salinity.

Irrigated soils receive a large amount of dissolved salts, either provided by irrigation water or by subsurface water.

Areas with that problem have been detected in the region irrigated by the Tunuyán Medio river (East Oasis). One of the most affected areas is that irrigated by the tertiary canal Chivilcoy. These limitations cause, at first, a dicrease in crop yields. Afterwards, due to their increase or persistence, they cause crop death.

For this reason, the area chosen to carry out the " **Research Program On Irrigation Performance "(RPIP)** involves irrigated areas in India, Pakistan, Egypt, Morocco and Argentina. The objective of this project is, among others, to obtain performance parameters of the irrigated areas as to environmental sustainability and drainage, including factors like soil and water salinity, ground water depth and quality, crop yields, etc.

It is important to point out that although the program started in 1992, this study was launched in December 1996.

The area under study is located within the irrigation area of the Tunuyán inferior, between carriles Chivilcoy-Anzorena-Costa canal Montecaseros and Pasera street. It is 8.4 km long, east to west, and 2,7 km wide, north to south. (Graph 1)

It has a cultivated surface of 1540 hectares, mainly with grapevines in the form of trellis and espalier. Next come fruit crops like plums, although the number of these has decreased in the last 10 years due to the fact that they have died out of root asphyxia and/or saline intoxication, both caused by the saline phreatic level rising.

Grapevines are more resistant to salinity and adapt their root system to the changes in phreatic water; that is why they have withstood this problem better. Although in the critical areas they are no longer grown, in the rest of the area they are still grown with low yields.

At present, approximately 10 % of the surface is uncultivated, and in the west of the area, along Tropero Sosa street up to carril Montecaseros, 25% of the farms were abandoned due to the problems mentioned above.

Tertiary Canal Chivilcoy is under a continuous shift seven days a week, and it supplies 13 tertiary canals. Each of these receives in its shift all the volume of the Chivilcoy canal. The shift time of each canal is 10 minutes per hectare with irrigation rights.

2-BACKGROUND

Several studies have been conducted in the area irrigated by the Tunuyán inferior river, where the area irrigated by the Tertiary Canal Chivilcoy is located.

Jorge Chambouleyron (1982) has developed for the area a model of operation and enhancement of the distribution of the hydric resource. This model divides the zone in 10 polygons, each corresponding to the area irrigated by a secondary canal. In turn, each of these polygons has been subdivided into nodes of approximately 1000 hectares.

Chambouleyron's model takes into account external and internal efficiencies and makes it possible to know the water depth that reaches each polygon or node from the water depth released by the diversion dam.

Salatino, E. (1985) designed a texture map of the first meter of depth of the soil, obtaining depth maps for 0-0.50 and 0.50-1mt

Mirábile,C. (1985) developed a map of soil salinity for 0-0.50 and 0.50-1mt depth, as well as maps of surface and ground water salinity through nodes and polygons.

Mirabile,C. (1985) launched a study of zone drainage and phreatic monitoring with monthly readings during the first two years, followed by bimonthly readings until 1995. Data are also obtained on a yearly basis about phreatic salinity and the composition of salts.

Mirabile,C. (1987) developed a model for saline hydric balance that takes into account the water depth applied to the polygon and/or node, soil and irrigation water salinity, texture, effective precipitation and evapotranspiration. This model also allows to know percolated water depth, the variation in soil salinity and the salt leaching water necessary to keep salinity constant or to reach the desired level. This makes it possible to know dynamically the process of salinization or desalinization according to the irrigation system used and the efficiency with which farmers irrigate their crops.

Mirabile,C. (1997), conducted a study on the factors that limit soil productivity in the area under study, analyzing the physical and chemical characteristics of the soil, the surface and subsurface water resource, the saline hydric balance and the problem with the level and quality of the phreatic water. In his conclusions he infers that, once the degradation problem has been detected, it is necessary to quantify its effect on crop yields.

3-OBJECTIVES

* To determine the incidence of soil salinity and phreatic levels on the yields of grapevine and plum crops.
* To correlate the factors mentioned above.
* To determine performance parameters related to phreatic depth, soil salinity and crop yields.

4- MATERIAL AND METHOD

Performance Parameters

The performance parameters adopted were those proposed by Bos M.

Phreatic depth:

$$\text{Relative phreatic depth} = \frac{\text{Real phreatic depth}}{\text{critical phreatic depth}}$$

Soil salinity:

$$\text{Relative EC ratio} = \frac{\text{Real EC value}}{\text{critical EC value}}$$

Farm Selection:

In September and October 1996, the area under study was surveyed in order to observe existent crops, their varieties, support systems, type and intensity of cultural work applied by farmers to their crops, technological capacity, soil types and their different limitations, etc.

It was observed that the most widely cultivated crops are grapevines (espaliers and trellises with "criollas" grapes (Creole grapes), D'Agen plums (for processing) and Santa Rosa plums (for fresh consumption), and peaches for processing.

The criterium adopted for farm selection was that they have crops of the same variety, similar age and cultural management. The only difference had to be soil salinity and phreatic depth.

Due to this homogeneity criterium, farms grown with peaches had to be left out , since most farmers grow a large combination of varieties using several different types of cultural management.

Finally, 12 farms were selected, grown with grapevines and plums on soils with different degrees of salinity. These farms were classified into good, fair and bad.(Graph 2)

Field work was conducted according to the following scheme:

crop	variety	farm type
grapevine (trellis)	Criollas	Good Fair Bad
grapevine (espalier)	Criollas	Good Fair Bad
plums	D'agen	Good Fair Bad
plums	Santa Rosa	Good Fair Bad

Installation of Phreatimetric tubes

In order to determine the variations in phreatic levels throughout the agricultural cycle, a network of 10 phreatimetric tubes 3 mt deep was installed in reticule shape in the area under study to relate the data measured in the field. (Chart 3).

Readings of phreatic levels were conducted in January, March, May, July and September, and they will continue to be performed every other month until completion of the study in April 1998. The salinity of the samples obtained (EC) has also been determined.(Chart 1-2).

As regards phreatic levels, up to the moment only phreatimetric tubes # 3 and 4 have been observed to show levels above 3 mt. Both are located on callejon Rodriguez between Tropero Sosa st. (to the west) and carril Montecaseros (to the east), a depressed area which had high phreatic levels until a few years ago. At present, those phreatimetric tubes register values between 2.30 and 2.70 mt.of depth and electric conductivity is around 6.9 dsm^{-1} for # 3 and 4.8 dsm^{-1} for # 4.

It should be pointed out that on callejón Rodriguez are located several farms whose perennial crops are semi-derelict or have been completely abandoned due to soil degradation caused by the presence of a highly saline surface phreatic water during the 80's and the first years of the present decade.

Extraction of soil samples:

The objective of sample extraction is to determine soil electric conductivity. Samples were taken in three different stages of the vegetative cycle of the selected crops: **beginning of the cycle** (august), **full cycle** (December) and **harvest** (January-February) for plums and (March-April) for grapes. Likewise, due to the root depth of these crops, samples were taken at two different depths: 0-0.70 y 0.70-1.40 mt. So far field samples have been taken and laboratory analyses have been performed corresponding to full cycle 1996, harvest 1996/97, and beginning of the cycle 1997/98. (Chart 3).

Field Measurements of Yields:

From mid-February to the end of April, the determination was performed of crop yields in each of the chosen farms. It corresponded to the harvest of the 96/97 vegetative cycle. (Charts 4 and 5).

As a complement to this determination , specially designed forms were analyzed, which had previously been given to the farmers of the chosen farms to record any climatic accident that might occur during the cycle, as well as a decrease in yields these may cause. In our area the most common accidents are: frost, hail, zonda wind, etc.

5-<u>RESULTS</u>

In spite of the short evaluation time so far, and the fact that the few data obtained can only be considered as trends, the following can be mentioned:

The salinity of surface water does not suffer variations in the different sectors of the area under study or throughout time, and the value of its electric conductivity is 1,3 dsm^{-1}.

Ground water, which supplements the irrigation shift (surface water) when the former is insufficient, is pumped from three different levels: superficial: 60-1.30 mt (bad quality water with 3,8 dsm^{-1}); middle: 1.30-1.80 mt, (fair quality with 1.7 dsm^{-1}) and deep: 1.80-3.00 mt. (better quality with 1.2-1.3 dsm^{-1}).

The static level of the acquifer in the area under study has not experimented considerable variations in spite of a hydrologic cycle of drought that started 4 to 5 years ago. Variation is small, approximately 1 mt only, and it is due to the fact that the area is far from the recharge zone of the acquifer, and that it is completely flat.

In the sector of the oasis close to the recharge zone, instead, the variation in static levels is approximately 40 mt., according to the information provided by the Centro de Aguas Subterráneas (Groundwater Center).

At present the area does not present problems with phreatic levels, since, out of the phreatimetric tubes installed, only two register phreatic levels. These phreatimetric tubes are placed relatively deep (2.70mt.), even in critical periods like the end of fall and spring.

There is no clear tendency in the dynamics of salinity between full cycle and harvest, since the amount of samples whose electric conductivity value increases is very similar to those whose value decreases.

Instead, there is a clear indication that at the beginning of the cycle (97/98), salinity is higher than it was during the harvest time (96/97).

It has also been noticed that in grape growing, both trellis and espalier, there is a similar behavior of salinity according to the different types of farms. In those labeled "bad", the high salinity of the soil continues increasing.

In "fair" farms, salinity during harvest decreased compared with full cycle and an increase in the harvest (increase in yields).

Conversely, in "good" farms, during harvest time salinity is higher than in full cycle and that at the beginning of the next cycle.

As to the relationship between salinity values and sampling depth, in the soils grown with grapevines there is no defined trend, which is otherwise noticeable in the soils grown with plums. In this case salinity increases with depth, and the higher the salinity of the soil, the higher the increase.

Even in good farms, the yields of the crops measured are lower than the potential yields obtained in those conditions. This may be due to the fact that, judging from their age, the crops have been planted and have grown during a period in which phreatic water was very high, and its salt content has deteriorated the soil. The crops, therefore, have had a restricted growth and development. Only in the last four years has there been a decrease.

6-<u>CONCLUSIONS</u>

The main conclusion is that the period of time devoted so far to taking samples is insufficient. Sampling has been carried out to evaluate results that interact with complex factors such as crop yields, soil salinity and depth, and quality of phreatic water.

The study performed so far requires at least 2 or 3 agricultural cycles for data collection. Likewise, the partial results obtained will make it possible to adjust the methodology for obtaining data about the parameters involved in order to achieve a better correlation.

7- BIBLIOGRAPHY

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Fig 1


Distribution of farms irrigated from somes tertiary canal
of Montecaseros's secundary canals
Carril Zapata
Carril Norte
Carril Montecaseros
1 km
N

Fig 2

PROPERTIES LOCATION

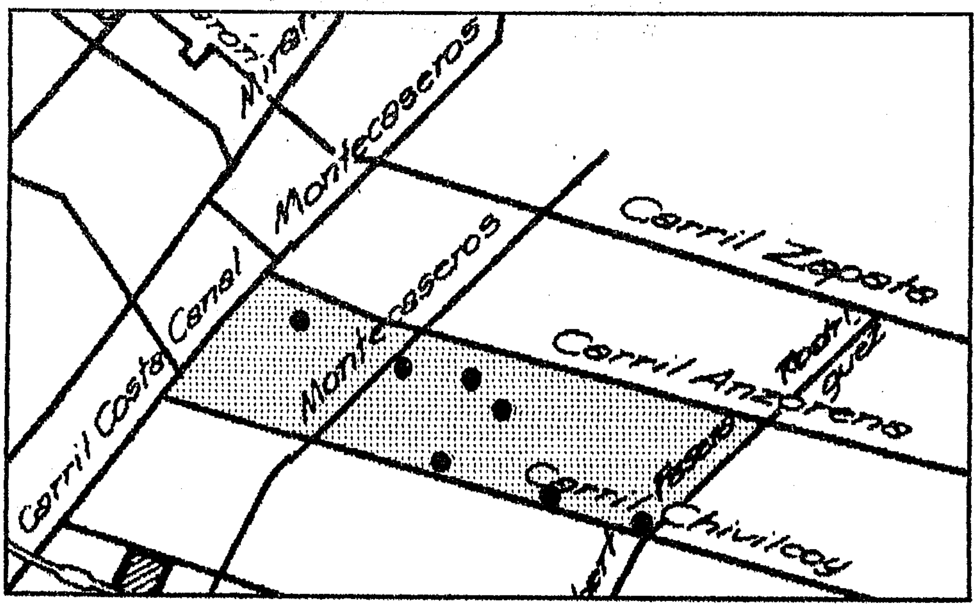
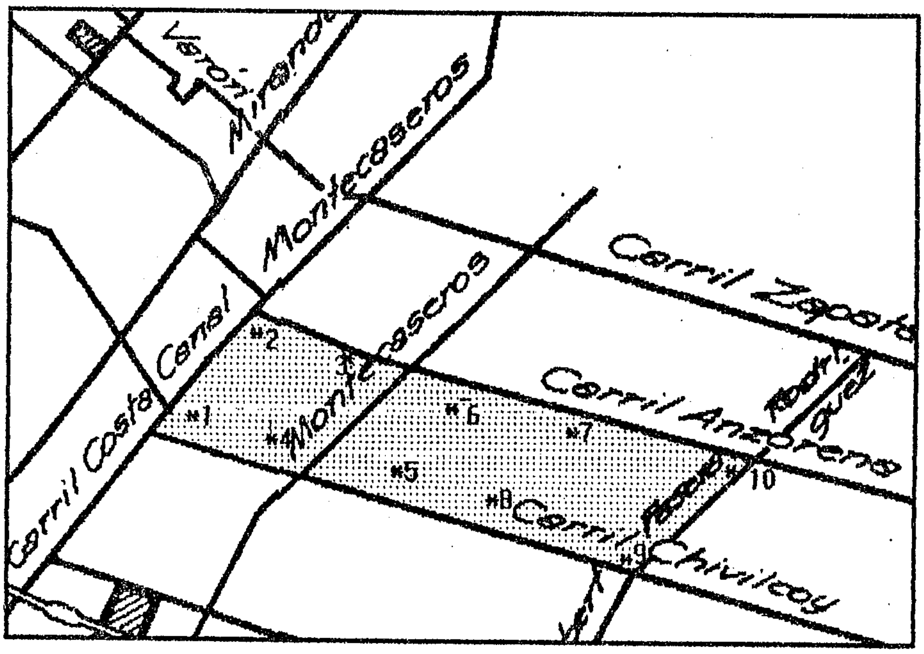


Fig 3

STUDY AREA AND SCHEME OF PHREATIMETRIC TUBE LOCATION.



APPENDIX

Chart #1: Phreatic Levels

values in meters

1997	1	2	3	4	5	6	7	8	9	10
January			2.40	2.20						
March			2.50	2.70	2.70					
May			2.50	2.70						
July										
September				2.50						
November										
1998										
January										
March										

Chart #2: Phreatic Salinity
Values in ds/mt-1

1997	1	2	3	4	5	6	7	8	9	10
January			6.9	4.8						
March			n/a	n/a						
May			n/a	n/a						
July			n/a	n/a						
September				4.70						
November										
1998										
January										
March										

Note: n/a means that it was not possible to take a sample to determine electric conductivity.

Chart # 3

Table of soil salinity.

value in ds/m.

Property	Crop	December´96		March´97		August´97		December´97		March´98	
		depth 0,75	depth 1,40	depth 0,75	depth 1.40	depth 0,75	depth 1,40	depth 0,75	depth 1,40	depth 0,75	depth 1.40
Terreni	Vid	7.52	5.65	10.40	9.4	16.5	14.3				
Pepe	Parral	4.87	4.91	3.20	3.05	8.21	6.10				
Fontana		3.78	4.11	2.91	6.24	3.20	3.29				
Callejon	Vid	5.77	5.62	8.57	9.05	22.6	11.4				
Pepe	Viña	2.69	4.30	2.76	3.20	3.57	3.29				
Fontana		3.11	3.00	8.53	3.05	2.45	3.97				
Galvan	Ciruela	5.82	12.4	2.17	7.80	10.9	13.00				
Pepe	Dágen	2.31	2.68	1.10	1.12	1.61	3.72				
Balestra		2.65	2.89	3.50	4.03	4.57	3.76				
Terreni	Ciruela	4.24	4.73	6.07	4.26	9.90	6.63				
Cardenas	Santa Rosa	3.85	4.14	11.1	7.61	6.43	8.06				
Balestra		2.71	2.95	3.20	1.73	3.83	3.78				

Chart #4: Crop yield (kg/hectare)

Trellis	Harvest ´97	Harvest ´98
Terreni	800 Kg/hectare	
Pepe		
Fontana	10000 kg/Hectare	

Espalier	Harvest ´97	Harvest ´98
Callejón		
Pepe		
Fontana	6000 kg/Hectare	

D´ agen Plum	Harvest ´97	Harvest ´98
Galván	3697 Kg/hectare	
Pepe	1660 kg/hectare	
Cárdenas	20000 kg/hectare	
Balestra	12000 kg/Hectare	

Santa Rosa Plum	Harvest ´97	Harvest ´98
Terreni	20000 Kg/hectare	
Cárdenas	19200 kg/hectare	
Balestra	12000 kg/Hectare	

Chart #5: Surface of plots under study

Farm	Crop	Area
Terreni	Parral	2 hectares
Pepe	Parral	12 hectares
Fontana	Parral	7 hectares
Callejón	Espalier	0.7 hectares
Pepe	Espalier	1.2 hectares
Fontana	Espalier	1 hectare
Galván	Dágen	0.648 hectares
Pepe	Dágen	9 hectares
Balestra	Dágen	10 hectares
Cardenas	Dágen	0.625 hectares
Balestra	Santa Rosa	5 hectares
Terreni	Santa Rosa	0.8 hectares
Cardenas	Santa Rosa	1.5 hectares