# Status of Water Distribution Uniformity and Efficiency in several on Farm Drip Irrigation Networks

## Some case studies in the Jordan Valley (Karamah)

**Foreword**

On behalf of his mission, as preliminary work, IRWA started during the early springtime 2006 to test six on farm irrigation networks, aiming to get three main goals:

- To gain knowledge of the average present hydraulic performance of the existing drip irrigation systems, commonly adopted by the farmers
- To identify the limiting factors due to improper materials (pumps, engines, pipes, providing appropriate tools for replacement, if needed), or due to bad operating system, thus providing the related directives.
- Finally, for to establish some demo plots inside those six pilot farms for practical demonstration regarding the optimization of irrigation water use, including fertigation.

The local Water Users Association (organized by GTZ - German Cooperation) helped for identifying those farmers among the members.

In addition, it helped greatly the work done during the preceding years in the irrigation sector by the French Mission (MREA) [1]

**Summary of the Main findings**

1. Filtration: not efficient in any case
2. Operating system: commonly bad, mainly because the excess of surface irrigated at once in respect to the flow/pressure allowed by the pump.
3. Mainline: undersized in 3 farms
4. Manifolds: undersized in 2 farms
5. Dripping lines: oversized (dripper's flow) in 3 farms

[1] **IOJOV PROJECT IN THE JORDAN VALLEY: PREREQUISITES TO RAISE EFFICIENCY IN IRRIGATED PERIMETERS -** Alice ARRIGHI de CASANOVA & Céline PAPIN
French Regional Mission for Agriculture and Water (MREA) March 2006

6. Pump/engine assembly: undersized in 2 farms
7. Pressure at the head: largely not sufficient in any case.

Consequently, as it was, no one farm presented hydraulic properties suitable enough for to ensure good water distribution uniformity (prerequisite for water scheduling and fertigation, which are the basics for the water use optimization). Thus any farm were eligible neither for pilot, nor for to establish demo plots, without proper restructure of the irrigation net and improvement of the operating system.

**General characteristics of all farms**

- Vegetables growing (August/September through May/June)
- At least one pond exists in every farm for to collect water from the JVA's (Jordan Valley Authority) controlled Turnouts (TO) at King Abdullah Canal (KAC).
- JVA is releasing water from the KAC's outlet twice a week.
- Water is then re-launched from the ponds by (diesel or electric powered) horizontal shaft centrifugal pump to the on farm distribution network.
- All farms are provided by one or more Farm Turnout Assembly (FTA), which controls the flow, the pressure and the volume at the JVA's pipe terminal.
- The farmer dismantles the internal irrigation network at the end of the growing season and reassembles it at the beginning. Not even the mainline is permanently buried.
- No hydraulic calculations are made in order to set up the assembly engine/pump-mainline-manifolds-dripping lines, nor for the operating system.

**Methodology**

The assessment of the actual hydraulic status and operating system of the on-farm irrigation net followed some main steps:

- Fixing the pump curve, by controlling the variation of flow in the main line, caused by the variation of the pressure at the pump outlet. This was necessary because the farmer doesn't have knowledge about his pump performance issues, nor any pump's documentation is currently available on farm.

- Checking the operating pressure in different points of the network, including the dripping lines, at constant pump's RPM/pressure.
- Taking the measures of the network (number/surface of the blocks irrigated at once, diameter/length of pipes, type/length of the dripping lines, presence/dimensions of plastic glasshouse) and creating a farm's map.
- Entering the irrigation system's data in the computer and processing them by proper modeling programme - in this case EPANET ( [2] ).
- Controlling the suitability of the network assembly by the computerized model, for to identify bottlenecks causing parasitic head losses (pipe length/diameter, fittings, curves) and for to recognize the proper operating system.
- Including in the calculation the head (elevation) required by proper filtration (sand + disks filters) and by the proportional injection tool for fertilizers (Dosatron).
- Providing to the farmer full technical support in order to reshape and operate properly his network.

**Note**: the dripper coefficient of variation - $CV_q$ - ( [3] ) wasn't included in the model's calculations of irrigation uniformity.

Some pictures too show the matter (last pages).

[2] EPANET is a program for analyzing the hydraulic and water quality behavior of pressurized pipe networks. It was developed by the U.S. Environmental Protection Agency's National Risk Management Research Laboratory. As such, it is public domain software that may be freely copied and distributed. A complete Users Manual as well as full source code and other updates can be downloaded from: www.epa.gov/ORD/NRMRL/wswrd/epanet.html.

[3] *Performance of drip irrigation systems under field conditions* - Felix Britz Reinders - General Manager: Operational Programmes, ARC-Institute for Agricultural Engineering, Private Bag X519, **SILVERTON** 0127, South Africa - "The new drippers' coefficient of variation (CVq) varies from an excellent 2,1% to a good 4,2% with an average of 3,12%. The CVq of the recovered drip lines from the field was a fair 6,5% in the first year and it worsened to a poor 8,2% in the second year".

**Table 1: The actual hydraulic status, as ascertained by the IRWA Experts**

| **No. of farm** | **FU** (Farm Unit) | **Actual** (Bars at head) | **After reshaping** (Bars at head) | **Suggested Changes** |
|---|---|---|---|---|
| **1** | 306 | 0,55 to 0,90 | 0,85 and 85% uniformity. | There are two options:<br>• Replace 253 m. of mainline (from ND 75 to ND 90) and irrigate 3 blocks at once, or<br>• Keep the old mainline, but irrigate 2 blocks at once.<br>NOTE: the 2nd option will hinder DOSATRON use, so that it's mandatory to adopt the first option. |
| **2** | 277 | 0,35 at the lateral's beginning | 1,1 and 97% uniformity | • Irrigate 8-9 blocks at once, instead of 17, in open field, and 9-10 greenhouses, instead of 19.<br>• Using DOSATRON, the pressure will decrease to 0,8 bars. |
| **3** | 194 | 0,45 | 1,1 and 89% uniformity | • Replace the pump (Pentax CM 50 125 B)<br>• Replace GR 16 mm. 8 l/h with GR 16 mm. 4 l/hour<br>• Replace 250 m. of the ND 50 mm manifold with ND 63<br>• Irrigate 4 greenhouses at once<br>• Irrigate one block by time in open field |
| **4** | 134 | 0,5 to 0,6 | 0,85 to 1,1 and 87% uniformity | • Replace 450 m. of the ND 75 mm mainline with ND 90<br>• Follow the recommended blocks number and sequence of opening (see the farm's file) |
| **5** | 265 | 0,5 | 0,9 minimum and 95% uniformity | • Replace the pump (Pentax CM 50 125 B)<br>• Replace GR 16 mm. 8 l/h with the same 4 l/hour<br>• Number of blocks irrigated at once and sequence as recommended (see the farm's file) |
| **6** | 151 | 0,4 to 0,5 | 0,95 and uniformity 90% to 93% | In open field:<br>• replace GR 16 mm. 8 l/h drippers with the same 4 l/h<br>• Irrigate at once 4 blocks only<br>In greenhouse:<br>• Change ND 50 mm manifold with ND 63<br>• Irrigate 5 greenhouse at once |

It appears very clearly, that the usual hydraulic status of the irrigation net inside the farms in the Jordan Valley can ensure a very low degree of water efficiency, because the low uniformity of distribution, which can actually average, optimistically, round 50% ( [4] ). A number of farms assessed beyond the ones here summarized (Table 4), showed the same status, with one exception only. Because "low water efficiency" means less biomass production per unit of provided water, it is possible to summarize this

[4] Because the very low pressure at the pump's outlet, it is impossible to ascertain the actual uniformity degree in percentage. In fact, below a certain threshold, the head loss cannot be calculated.

condition as follow: ***great part of the irrigation water used in the Jordan Valley is simply lost***. As reported by the common bibliography ( [5] ),improving the uniformity - thus the efficiency - from 70% to 90% allows to increase up to 50% the irrigated area by the same quantity of water.

**NOTE. The revealed actual low level of uniformity/efficiency puts off the implementation of fertigation and irrigation scheduling: the most important evolution toward any improvement of the water use efficiency.**

**Table 2: Pumping Stations, Dripping lines and Operating System**

| No. | FU | Actual | Change | Remarks regarding irrigation system steadiness |
|---|---|---|---|---|
| **1** | 306 | 7,5 KW | Any | The pump can meet the needs, if:<br>• the number of blocks irrigated at once is reduced from 3 to 2, or<br>• the main line is adjusted from ND 75 to ND 90 (253 m.) |
| **2** | 277 | Diesel | Any | The pump can meet the needs, if<br>• the number of blocks irrigated at once in open field is reduced from 17 to 8-9 and<br>• under plastic glasshouses from19 to 9-10 |
| **3** | 194 | 3,0 KW | 7,5 KW | The pump is adequate if the manifold ND 50 will be replaced by ND 63 (253 m.) |
| **4** | 134 | Diesel | Any | The pump can meet the needs if the main line ND 75 is replaced by ND 90 (450 m.) |
| **5** | 265 | 3,0 KW | 7,5 KW | Replacing the pump by a more powerful one will not be enough, unless the dripping lines too will be changed from 8 l./h - 40 cm spaced and 16 mm diameter to the 4 l/hour ones. |
| **6** | 151 | Diesel | Any | The pump can meet the needs if 115 m. of main line ND 50 will be replaced by ND 63 |

The broad frame resulting from this table enlightens that there are two orders of inaccuracy: in the design of the irrigation net and in his operating system. Regarding the design:

- all pumps are working below or above their potential, thus increasing in any case the cost of the energy required per $m^3$ of impelled water
- several mainlines or manifolds originate parasitic head losses and must be replaced by higher ND pipes
- the common adoption, in this area, of the 8 l/h drippers, spaced 40 cm. and mounted on 16 mm pipe, is apparently the cheapest way for the initial investment, but almost in any case is increasing the running costs and causes unevenness inside the system

[5] HAWKE'S BAY REGIONAL COUNCIL - Ext. Bulletin Nov. 2004 - "*Increasing a system's distribution uniformity (i.e. evenness of irrigation) from 70% to 90% can allow 50% more area to be irrigated from the same volume of water*".

- As general remark, this dripping line commonly used isn't the best choice, in particular when the lines are longer than 30 meters. Much more suitable are the 4 liters/hour drippers.

Regarding the operating system, almost in any case is necessary to resize the number and/or the sequence of the blocks operated at once.

**Table 3: Filtration**

| No. | FU | Actual | Change |
|---|---|---|---|
| **1** | 306 | Screen type very old and full ineffective | Double sand filter 700 mm diameter and disks filter |
| **2** | 277 | Old screen filters (without...screen) | Double sand filter 700 mm diameter and disks filter |
| **3** | 194 | Old sand and screen filters | Single sand filters 750 mm and disks filter |
| **4** | 134 | Old sand and screen filters | Double sand filter 750 mm and disks filter |
| **5** | 265 | Old screen filter | Double sand filter 750 mm and disks filter |
| **6** | 151 | Two old ineffective disks filters | Double sand filter 700 mm diameter and disks filter |

Due to the very bad quality of water (both organic and physical spoiling/polluting agents are present), it is mandatory to adopt the sand filtration. Followed by disks filter as ultimate precaution

The upgraded sand filters, provided by IRWA, are of the vertical type (designed by MREA - Mission Regionale Eau and Agriculture - see also the last picture hereafter), for to ensure the best backflushing cleaning action, and provided by proper filtering media (silica sand, 0,8-1,2 mm size).

As general observation, an efficient on farm filtration system is almost unknown overall in the Jordan Valley: likely the drip irrigation system took place here in a rush way, without considering adequately his prerequisite: the quality of the used water.

Thus the existing traditional "sand filters" are useless, because their horizontal design, the absence of proper bottom diffusers and because the used media (gravel instead of silica or quartzite sand 0,8-1,2 mm).
Those filters can be considered as bare head losses.

The outcomes are common to the majority of the farms: quick worsening of the drippers, increasing lack of uniformity, due to the increased CVq (coefficient of variation among drippers, thus along the line) , and dripper's clogging, which leads to replace the lines every two years or even yearly, in some cases, thus an extra-cost for the farmer.
The sand/disks filters assembly, provided by IRWA, will match the head losses allowed within the newly calculated irrigation system.

**Table 4: list and hydraulic status of farms assessed beyond the six pilot ones.**

| | **Actual uniformity/pressure (m.)** | **Uniformity/pressure after improving** |
|---|---|---|
| Ghor el saffi | **3,5 m** not sufficient for to operate the system | **92%** with about **10,0 m** head at the emitter. |
| Karamah | **5.7 m** not sufficient for to operate the system | **81%** with about **10,0 m** head at the emitter. |
| Karamah | **3,0 m** not sufficient for to operate the system | **96%** with more than **10,0 m** head at the emitter. |
| Karamah | **3,4 m** not sufficient for to operate the system | **87%** with about **10,0 m** head at the emitter. |
| Karamah | **15, 0 m**, more than one type of drippers. | **96%**, with **11,0 m** head at the emitter |
| Karamah | **2.3m** not sufficient for to operate the system | **84%** with **9,5 m** head at the emitter |
| Karamah | **4,0--5,0 m** not enough to operate the system | **87%**with **9,1-9,9 m.** at the emitter |
| Karamah | **1,4 m** not sufficient for to operate the system | **92%** with **10,0 m**. at the emitter |
| Karamah | **6,5 m** not sufficient for to operate the system | **85%** with about **10,0 m** head at the emitter. |
| Karamah | **1,0-7,0 m** not sufficient for to operate the system | **90%** with about **10,0 m** head at the emitter. |
| Karamah | **4,0 m** not sufficient for to operate the system | **83%** with about **9,5 m** head at the emitter. |
| Karamah | **5,0 m** not sufficient for to operate the system | **87%**, with **10,0 m** head at the emitter |

**SHARP CONCLUSION: in order to optimize the water use, *the reassessment of the existing irrigation nets inside the farms (several thousand) in the Jordan Valley appears mandatory and preliminary to any water saving policy.***

Common on farm pond, often invaded by algae. In this case, an old under-sized screen filter is placed between the diesel pump and the irrigation net.

Lack of watering uniformity: the second row appears under irrigated, whilst the adjacent rows show large over watering.

Checking the flow on the mainline by the portable ultrasonic clamp flowmeter

The standard inlet at the TO on the KAC: the quality of water is quite bad and the preliminary filtration clearly unsatisfying.

Before and after