DRIP AND FILTRATION EQUIPMENT'S PERFORMANCE
EQUIPEMENT DE FILTRATION ET GOUTTE DE LA PERFORMANCE

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ABSTRACT

Drip irrigation together with the heart of the system, its filtration, is considered as one of the most efficient irrigation systems. However it is of utmost importance to correctly select, plan, design, install and to properly maintain it for the successful long-term operation.

Since the first congress was held in Tel Aviv, Israel from the 6-13 September 1971, 40 years of progress and development took place in the drip irrigation industry and many types of drippers and filters are available today.

Research was carried out by the Agricultural Research Council's-Institute for Agricultural Engineering (ARC-IAE) on two drip irrigation companies' drip irrigation equipment and eight different irrigation filters (sand, disc and screen) to determine the performance of the drippers and the filters. Evaluations were also carried out in the laboratoryand in the field under farming conditions.

The results of the project showed that the good performance of the different drippers and filters can be maintained when a proven maintenance schedule is followed.

RÉSUMÉ ET CONCLUSIONS

Irrigation goutte à goutte avec le cœur du système, sa filtration, estconsidérécommel'un des systèmesd'irrigation plus efficaces. Cependant, ilest primordial de bienplanifier, installer, sélectionner, concevoir et de bienl'entretenir pour le succès à long termel'opération.

Depuis le premier congrès a eu lieu à Tel Aviv, Israël, depuis le Septembre 6-13 1971, de 40 ans de progrès et de développement a eu lieu dansl'industrie irrigation goutte à goutte et de nombreux types de goutteurs et les filtressontdisponiblesaujourd'hui.

Des recherchesontétéeffectuéesparl'Agricultural Research Council's Institute for génieagricole (ARC-IAE) surtroissociétésd'équipementd'irrigation au goutte 'irrigation goutte à goutte et l'irrigationhuitfiltresdifférents (sable, le disque et l'écran) pour déterminer la performance de l'goutteurs et les filtres .

Les évaluationsontégalementétéeffectuéesdans le laboratoireet le terrain sous les conditions d'élevage.

Nouveau émetteursréguliers "coefficient de variation moyen (CV_Q) a été un excellent 2,2% et la pressioncompenséeémetteurs« moyenne CV_Qest un bon 3,2%. Avec le site de la ferme des évaluations du coefficient (CV) a varié d'un marginal de 9,1% à un pauvre 42,8%. L'uniformitéd'émission (EU_A) ontvarié d'un bon 89,1% à 61,6% un niveau inacceptable.

Les systèmes de filtration sontconsidéréscomme le cœurd'une exploitation du systèmed'irrigationgoutte-à-succès, car une filtration efficaceassiste pour éviter de

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boucher les goutteurs. Lorsque le colmatage se produitdans les systèmesd'irrigationgoutte-à-, il en résultedansl'utilisationinefficace de l'eau et la perte de rendementsoptimaux. Le choix optimum économique d'un filtre, ainsique le type de filtre qui convient le mieuxdans les zones de ressources en eau a souligné avec différentesqualitésd'eauestd'une importance capitale et ilestdonc important de connaître les performances du système de filtration.

Évaluationssur le terrain ontétéréalisées en quatresaisonssurdeuxanssur les 29 exploitations danscinqrégionssur six modèles de filtre.L'indicesaleté (DI) des sources d'eaudans les gammes de cinqrégions du propre (DI <1%) à très sale (DI = 43%) et les filtresontréussi à nettoyerl'eau à un niveau de DI entre 0,15% et 10,0%. L'efficacité de filtration des filtresvarie entre 31,0% à 96,6%. En moyenne, les efficacités de filtration des filtresdifférentsontétécomme suit: filtres à sable de 89%, 52% des filtres à disqueset les filtresd'écranautomatique de 20%. Avec le test de gestion de lavage, les filtres à sable utiliséunemoyenne de 1,63 m^3, les filtres à disques 0,37 m^3 et l'écran des filtres 0,15 m^3 d'eau par lavage. Cependant, les filtresd'écranet le disque lavage plus régulièrementque les filtres à sable. Troisfiltres à disques, deuxfiltres à sable ettroisfiltresautomatiquesontétéintensivementtestédans le laboratoire ARC-IAE dans des conditions contrôlées. L'efficacité de filtration des filtres de sable étaient 98,5%, le disquefiltres 50,5% et l'écranautomatique de filtres 55,4%. Avec l'efficacité lavage, il a étéconfirméque le débitd'aumoins 60 (m^3 / h) / m^2 devraitêtreutilisé pour obteniruneefficacité de 90 à 100% avec lavage des filtres à sable. L'efficacité lavage des filtres à disqueétait un peu 33,1% et avec les filtresautomatique de l'écran, un pourcentaged'eau de lavage a étédéterminée et seulement 3,5% de l'eaufiltrée a étéutilisé pour nettoyer les filtres. Les résultats du projetontmontréque la performance de l'goutteurs different filters peuventêtre maintenueslorsque le calendrier de maintenance éprouvéeestsuivie.

INTRODUCTION

South Africa is a dry country with a rainfall below world average, which is distributed unequally over the country. On average South Africa receive only 470mm per annum. This rainfall is also highly irregular in occurrence and the demand for water has created pressure for the optimal use of all water. Therefore, many farmers invest in drip irrigation as an improved or most efficient irrigation method for water conservation. From this research it was pointed out that this system can also be inefficient as a result of water quality, mismanagement and maintenance problems.

The South African National Water Act (Act 36 of 1998) makes provision for water to be protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner to the benefit of all people in South Africa. Currently, sub-surface drip systems account for 7 500 hectares of the total of 150 000 hectares of drip irrigation in South Africa out of a total of 1 600 000 hectares. To assist the users to utilise their systems effectively, research was carried out to determine the performance of various types of drippers and filters in a laboratory. Together with that, the performance and blockage potential of drippers and filters under field conditions were also evaluated.

METHODOLOGY

An extensive literature study on all facets that can influence the different types of drippers and filters under field conditions was undertaken. Aspects that were addressed in this study include water quality, water treatment methods, inherent factors that affect emitter performance, filtering, system maintenance and design.
Emitters and filters for the investigation were selected on the basis of the various emitter types generally used in South Africa, and on the number of years the various emitters and filters were in use to determine the effects of age on their performance.

Drippers selected
The Drip-In Regular and Agridrip Pressure Compensated (see Table 1) and Ram Pressure Compensated (see Table 2) drippers were selected, as they were the most commonly used drippers for surface drip in South Africa. The performance of these new drippers, ten models in total, was evaluated under controlled conditions in a hydraulic laboratory.

Table 1. Particulars of the Drip-In Regular and Agridrip Pressure Compensating emitters
Tableau 1. Renseignements Drip-in régulière et Agridrip émetteurs de compensation de pression

Code	Emitter description	Nominal discharge (ℓ/h) @ 100 kPa	Flow-path (labyrinth) particulars			
			Depth (mm)	Width (mm)	Length (mm)	Type
GA	12 mm 2 ℓ/h Regular	2	0,9	1,0	155	Non compensating long flow-path turbulent flow in line emitter.
GB	12 mm 4 ℓ/h Regular	4	0,9	1,0	49	
GC	16 mm 2 ℓ/h Regular	2	0,95	1,0	183	
GD	16 mm 4 ℓ/h Regular	4	1,28	1,4	158	
KE	16 mm 2,2 ℓ/h Pressure Compensating (PC)	2,2	1,0	0,95	40–250	Pressure compensating varying flow-path length, turbulent flow in line emitter.
KF	16 mm 3,6 ℓ/h Pressure Compensating (PC)	3,6	1,35	0,95	40–250	

Table 2. Particulars of the Ram Pressure Compensating (PC) emitters
Tableau 2. Détails de compensation de pression Ram (PC) émetteurs

Code	Emitter description	Nominal discharge (ℓ/h) @ 100 kPa	Flow-path (labyrinth) particulars			
			Depth (mm)	Width (mm)	Length (mm)	Type
KG	17 mm 2,3 ℓ/h PC	2,3	1,15	1,15	22	Pressure compensated integral lateral, turbonet flow-path, self-flushing with pressure difference.
KH	17 mm 3,5 ℓ/h PC	3,5	1,20	1,75	22	
KJ	20 mm 2,3 ℓ/h PC	2,3	1,15	1,15	22	
KK	20 mm 3,5 ℓ/h PC	3,5	1,20	1,75	22	

In the empirical study, professionals in various disciplines, e.g. design, scheduling, maintenance and supply of equipment were contacted in order to obtain information regarding clogging problems experienced in the various drainage regions in South

Africa. Drippers prone to physical, chemical and biological clogging problems occurring in South Africa and used on a large scale in different regions right across the country, were included in the investigation.

With regard to the field evaluation, six catchment areas in South Africa were identified (see Figure 1), namely the Berg, Breede, Orange, Kouga and Crocodile rivers, together with the Vivo region where farmers experience problems with drippers that clog. In these areas, a total of 42 systems were identified and selected on a basis of dripper type and dripper age. Dripper systems younger than five years and those older than five years were identified. These systems' performance was evaluated in the field twice a year for two consecutive years, according to ASAE EP 458 (1997). Apart from the performance evaluations, data was also collected of the maintenance schedules and water samples were taken for water quality analysis.

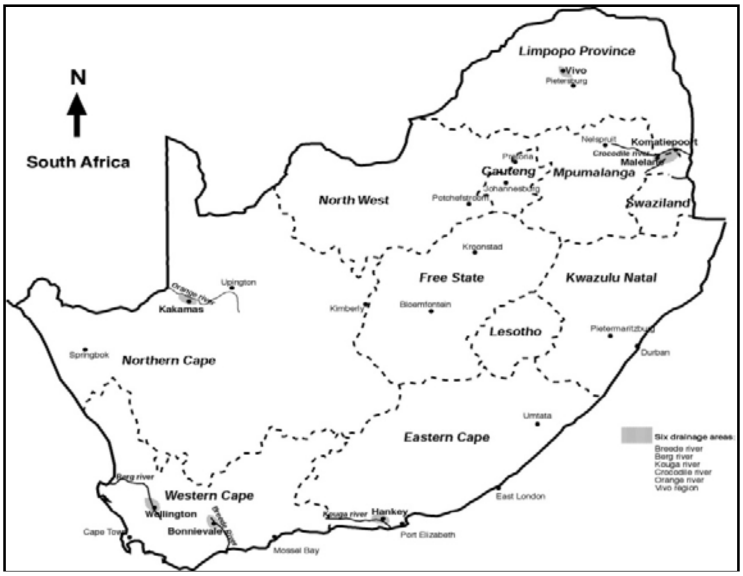

Figure 1. Drainage regions where investigations irrigation took place

Figure 1. Régions de drainage oùl'enquête à goutte aeu lieu

After the field evaluation, one dripper line was sampled out of the relevant block and replaced with the same dripper type. Evaluations were then carried out in the ARC-IAE Hydrolab to determine possible causes of clogging. This was repeated the following year.

Filters selected

The Filters from four Companies that were selected are shown in Table 3. They were selected as they were the most commonly used (80% of the time) filters for micro-irrigation in South Africa.

Table 3. Filters that were selected

Tableau 3. Les filtres qui ontétésélectionnés

Code	Type	Name of Filter
AS	Sand	Silicon II 41 sand filter (80mm)
BC	Screen	Amiad self-cleaning screen filter (Taf 3)(80mm)
CC	Screen	Amiad self-cleaning screen filter (Saf 3000)(150mm)
DS	Sand	Sandfil 40 / Conn 40 sand(80mm)
ED	Disc	Arkal Spin Klin® disc filter (Three-Filter unit)(100mm)
FD	Disc	Arkal 3 disc filter (Arkal 3 Twin)(80mm)
GD	Disc	Amiad 3 disc filter(80mm)
HD	Disc	Terbus cyclonic disc filter(80mm)

Laboratory tests on drippers

The new drip lines with emitters were tested under controlled conditions in the hydro laboratory of ARC-IAE for average discharge ($\bar{q}$) and for the manufacturing coefficient of discharge variation (CV_q). These values were used as a reference base in the evaluation of the experimental site and infield performance of the particular emitter types. Both $\bar{q}$ and CV_q were determined for a total sample of 100 emitters, as well as for four groups of 25 emitters in accordance with the International Standards Organisation (ISO/TC 23/SC 18 N 89, 1983) and expressed as in equation 1 to 3:

$$\bar{q} = \frac{1}{n}\sum_{i=1}^{n} q_i \qquad (1)$$

$$S_q = \left[\frac{1}{n-1}\sum_{i=1}^{n}(q_i - \bar{q})^2\right]^{1/2} \qquad (2)$$

$$CV_q = \frac{S_q}{\bar{q}} \times 100 \qquad (3)$$

Where: q_i = emitter discharge rate (ℓ/h);
n = number of emitters of the sample;
$\bar{q}$ = mean of all the measured discharge rates (ℓ/h);
S_q = standard deviation of the discharge rate of the emitter; and
CV_q = coefficient of variation of discharge rate of the emitters (%).

The coefficient of manufacturing variation (CV_q) is used as a measure of the anticipated variation in discharge for a sample of new emitters. The CV_q is a very useful parameter with rather consistent physical significance, because the discharge rate for emitters at a given pressure is essentially normally distributed.Criteria for CV_q is tabled in Table 4**.**

Table 4. Criteria for CV_q (%) of "point-source" drippers
Tableau 4. Critères pour CV_q(%) des "point-source" goutteurs

Classification	ASAE EP 405.1 (1997)	Classification	ARC-IAE	ISO
Excellent	<5	Excellent	0,1 – 2,5	
Average	5 – 7	Good	2,6 – 5,0	0,1 – 5,0
Marginal	7 – 11	Fair	5,1 – 7,5	
Poor	11 – 15	Marginal	7,6 – 10	5,1 – 10
Unacceptable	>15	Poor	>10	>10

Field evaluation of drip systems

A complete system evaluation was done according to the procedure described in ASAE EP 458 (1997) where five dripper lines were evaluated at five positions. Apart from the $\bar{q}$ andCV_q, the statistical discharge uniformity (U_s) were also calculated as shown as equation 4:

$$U_s = 100 - CV_q \qquad (4)$$

Where: U_s = Statistical uniformity of emitter discharge rate (%).

A U_s value of 80% or higher is normally considered as an acceptable criteria (ASAE EP 458, 1997).

The field emission uniformity (EU′) was also used to judge the uniformity of emitter discharges within an irrigation block and is shown as equation 5:

$$EU' = 100 \frac{q'_{min}}{\bar{q}} \qquad (5)$$

Where: EU' = field emission uniformity (%);

q'_{min} = Measured mean of lowest ¼ of emitter discharge (ℓ/h); and

$\bar{q}$ = Measured mean emitter discharge (ℓ/h).

Table 5 reveals a comparison between U_s and EU as suggested for design purposes:

Table 5. Comparison between U_s and EU for design purposes (ASAE EP 458, 1997)

Tableau 5. Comparaison entre nous et EU à des fins de conception (ASAE EP 458, 1997)

Classification	U_s (%)	EU (%)
Excellent	95 – 100	94 – 100
Good	85 – 90	81 – 87
Acceptable	75 – 80	68 – 75
Poor	65 – 70	56 – 62
Unacceptable	<60	<50

Laboratory tests on filters

The performance of the filters, eight models in total, was evaluated under controlled conditions in the hydraulic laboratory of ARC-IAE.It is a re-circulating system, consisting mainly of two reservoirs, a pump, pipes, valves, two Dirtiness Index meters, electric pressure- and flow sensors and instrumentation that display all the signals and that have two-way communication with the controlling computer.

With this test bench, the dirtiness of the water was changed and the following were closely monitored and recorded:

- total volume that was filtered;
- the flow-rate through the filter;
- the pressure differential; and
- the dirtiness index before and after the test.

The Dirtiness Index Meter, developed by (ARC-IAE) was used to determine the dirtiness index. The instrument works on the principle that a quick blocking test is done under controlled conditions on a screen similar to that of the filter for which the dirtiness of the water is measured. This is determined by measuring how many litres of water can be forced through the small screen by a pressure rise of 50 kPa against the screen.

The dirtiness index (DI) was calculated twice before the filter and twice after the filter. The DI is calculated according to the following equation:

$$DI\ (\%) = \frac{\text{Screen Factor (F)}}{\text{Volume through flow} - \text{meter } (\ell)}$$

Where: F = $6{,}32 \times 10^{-3} N^{2.1}$

N = fineness of the screen in microns.
The results were averaged and used in the following equation to calculate the efficiency of the filter:

$$\text{Filtration Efficiency} = 100\left(1 - \frac{\text{DI after filter}}{\text{DI before filter}}\right)\%$$

To determine the backwash efficiency, five tests were done at different dirtiness indexes, ranging from 2% up to 50% dirtiness of the water, and a graph was drawn (Figure 2) of volume water filtered against dirtiness index at a head loss *increase* of 50 kPa over the filter. For these tests the filter elements were thoroughly hand-cleaned before each clogging test. After these tests, the same tests were repeated, but this time the filters were backwashed and not hand-cleaned.

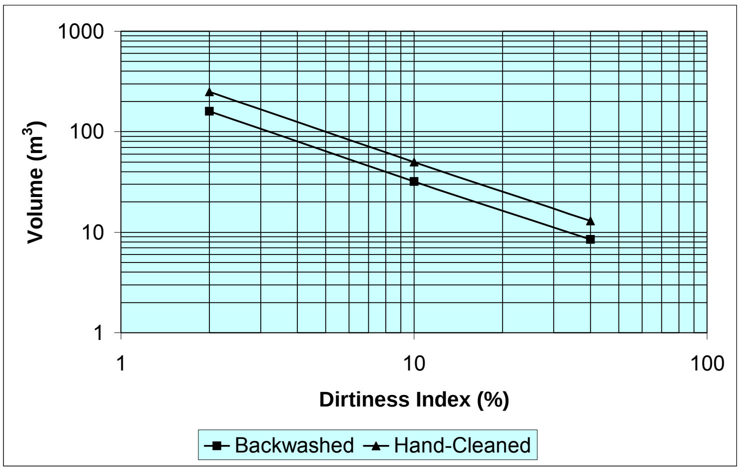

Figure 2. A typical filtration capacity curve of a filter
Figure 2. Unecourbe de filtration typiquescapacité d'un filtre

The volumes that were filtered at the same DI during the two tests (hand-cleaning and backwashing) were read from the graph. With these volumes the backwash efficiencies were calculated according to the following equation:

$$\text{Backwash efficiency} = \frac{\text{Volume filtered at } DI_n \text{ with backwashing}}{\text{Volume filtered at } DI_n \text{ by clean filter}} \times 100$$

Where: DI_n = Dirtiness Index of a specific value.

Simultaneously, field evaluations were carried out in five regions, as shown in Figure 1, around the country where sand, silt, or organic contamination in the water were problems. The areas were:

- Orange River Valley, Kakamas – sand/silt problems
- Berg River Valley, Paarl – organic problems
- Breede River Valley, Robertson – organic problems
- Sundays River Valley, Kirkwood and Addo – sand/silt problems
- Kouga River Valley, Patensie – organic problems

In each of these areas, three filter stations of the different filter types were selected for testing. At each site, a questionnaire was completed to record the details of the filter station and the filtration management practices. The backwash management test entails the measurement of the different pressures and the flow-rate of backwash water. For the filtration efficiency a portable Dirtiness Index meter was used in the test procedure.

RESULTS

Laboratory tests on new drippers

The results of the discharge/pressure relationship and the coefficient of discharge variation (CV_q) tests performed in the laboratory on emitters are summarised in Tables 6 to 8.

Table 6. Laboratory results of Drip-In Regular emitters
Tableau 6. Les résultats de laboratoire du Drip-In émetteurs réguliers

Emitter description			Discharge test				CV_q Test (P =100 kPa nominal)				
			Discharge (ℓ/h)			Discharge Exponent	Discharge (ℓ/h)				CV_q (%)
Code	mm	(ℓ/h)	100 kPa	200 kPa	300 kPa		Max	Min	Av	Var (%)	
GA	12	2	2,23	3,19	3,93	0,5163	2,5	2,1	2,2	18,2	2,1
GB	12	4	4,07	5,77	7,07	0,5016	4,5	3,8	4,1	17,1	3,8
GC	16	2	2,26	3,25	4,01	0,5207	2,6	2,2	2,3	17,4	2,4
GD	16	4	4,25	6,07	7,46	0,5115	4,7	4,1	4,3	14,0	2,2
									Average CV_q		2,6
									Classification		Good

Table 7. Laboratoryresults of Agridrip Pressure Compensating (PC) emitters
Tableau 7. Résultats du laboratoire de compensation de pression Agridrip (PC) émetteurs

Emitter description			Discharge test (Average P)				CV_q Test (P = 200 kPa nominal)				
			Discharge (ℓ/h)				Discharge (ℓ/h)				CV_q (%)
Code	mm	(ℓ/h)	100 kPa	200 kPa	300 kPa	400 kPa	Max	Min	Av	Var (%)	
KE	16	2,2	2,56	2,44	2,38	2,38	2,7	1,6	2,4	45,8	4,2
KF	16	3,6	3,84	3,58	3,57	3,66	3,8	3,3	3,6	13,9	3,4
									Average CV_q		3,8
									Classification		Good

Table 8. Laboratory results of Ram Pressure Compensating (PC) emitters
Tableau 8. Résultats du laboratoire de compensation de pression Ram (PC) émetteurs

Emitter description			Discharge test (Average P)				CV_q Test (P = 200 kPa nominal)				
			Discharge (ℓ/h)				Discharge (ℓ/h)				CV_q (%)
Code	mm	(ℓ/h)	100 kPa	200 kPa	300 kPa	400 kPa	Max	Min	Av	Var (%)	
KG	17	2,3	2,47	2,41	2,45	2,51	2,4	2,1	2,3	13,0	2,6
KH	17	3,5	3,72	3,65	3,78	3,74	4,2	2,5	3,6	47,2	4,0
KJ	20	2,3	2,53	2,40	2,46	2,45	2,5	2,0	2,3	21,7	3,9
KK	20	3,5	3,68	3,50	3,60	3,47	3,6	3,2	3,4	11,8	2,6
									Average CV_q		3,3
									Classification		Good

Abbreviations used in the tables:
P: Operating pressure (kPa)
Max: The discharge of the emitter with the highest discharge in the sample (ℓ/h)
Min: The discharge of the emitter with the lowest discharge in the sample (ℓ/h)
Av: The average discharge of the sample of 100 emitters (ℓ/h)
Var: The variation in discharge between the emitters with the highest and lowest discharge (%)
CV_q: Coefficient of discharge variation of the sample (%)

Laboratory results on used drippers

Both $\overline{q}$ and CV_q tests were conducted on lines recovered from the field and results are presented in Table 9 and 10. The percentage of drip lines recovered from the field of which the average discharge of the emitters showed: (a) a *reduction* relative to the average discharge of new emitters, (b) *no significant deviation* from the average discharge, and (c) an *increase* relative to the average discharge of new emitters, is shown in Table 9 for two consecutive years of sampling.

Table 9. Percentages of drip lines with emitter discharges deviating from the average discharge of new emitters
Tableau 9. Pourcentages des lignes d'égouttement avec des décharges émetteur s'écartant de la décharge moyenne de nouveaux émetteurs

Emitter type	Reduced discharge (%)		Average discharge (%)		Increased discharge (%)	
Year of sampling	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Agriplas Drip-In Regular (Non-compensated)	50	54	8	25	42	21
AgriplasAgridrip (Pressure compensating)	0	0	0	0	100	100
Netafim Ram (Pressure compensating)	16	6	21	12	63	82

Dripper lines with regular emitters showed a general tendency towards reduced average discharge due to partial or total clogging of drippers. Drip lines with pressure compensated emitters on the other hand showed a general tendency towards increased discharge.
A summary for CV_q for two consecutive years is shown in Table 10.

Table 10. Summary of the average Coefficient of Variation (CV_q) of the new and used drip line
Tableau 10. Résumé de la coefficient de variation moyen (CV_q) de la ligne de goutte à goutte neufs et d'occasion

Emitter type	New CV_q (%)	Used Year 1 CV_q(%)	Used Year 2 CV_q(%)
Drip-In 4 ℓ/h, 16 mm	2,2	5,6	6,6
Agri PC 3,6 ℓ/h, 16 mm	3,4	9,1	7,8
Ram 3,5 ℓ/h, 17 mm	4,0	6,6	8,0
Average CV_q	3,0	6,5	8,2
Classification	Good	Fair	Marginal

The average CV_q of new pipes worsened from a good value of 3,0% to a fair value of 6,5% in year 1. For the year 2, it worsened even further to a marginal value of 8,2%. Factors contributing to these worsening results are clogging and/or increased discharges due to ineffective pressure compensation.

Drip lines recovered from the field were generally in good condition, although some were in bad to very bad shape. A common observation was that, especially where drip lines were heavily soiled and emitters badly clogged, many of the emitters were pierced, apparently in an effort to open clogged emitters. One or two cases also occurred where the drip line itself was badly damaged and with leaking holes in it. In other cases, button emitters were added to a drip line where the original emitters were heavily clogged, or drip lines consisted partly of one make of emitter and partly of a different make and/or model of emitter.

Field evaluation results of drippers

The statistical discharge uniformity (U_s) was determined for all the types of drippers in the different regions. As a U_s value of higher than 80% is considered acceptable (ASAE EP 458, 1997), Table 11 was developed to classify the systems according to this value.

Table 11..Drippers classified according to the statistical discharge uniformity (U_s) for all the regions
Tableau 11. Les goutteurs classés en fonction de l'uniformité de décharge statistique (U_s) pour toutes les régions

Age (years)	U_s value (%)	Number of systems		
		Dripper type		
		Ram PC	Agridrip PC	Drip-In Regular
<5	>80	8	2	6
	<80	2	2	4
>5	>80	8		5
	<80	1		4

With regard to the statistical uniformity discharge coefficient (U_s), the Ram PC met the requirements in 84% of the cases, the Drip-In Regular in 58% of the cases and the Agridrip PC in only 50% of the cases. For all three dripper types, no significant conclusion could be reached that the age of the pipe played a role in the degree of clogging. However, it was evident that incorrect or no maintenance of the drip systems contributed in most cases to the decreased performance.

In the field, the pressure compensated drippers performed percentage wise better than the regular drippers, regardless of years installed.

The field emission uniformity values (EU′) were also determined for the drip irrigation systems and are shown in Table 12.

Table 12. The average EU′ values per dripper type per age group under field conditions in percentage

Tableau 12. La moyenne deEU′ les valeurs par type de goutteurs par groupe d'âge dans des conditions de terrain en pourcentage

Dripper type	Age	Date			
		Okt Year 0	May Year 1	Okt Year 1	Apr Year 2
Ram PC	<5 year	88,5	87,6	86,3	84,8
	>5 year	89,8	88,7	88,6	88,2
Agridrip PC	<5 year	89,5	86,3	86,9	75,2
Drip-In Regular	<5 year	86,4	82,9	76,6	80,9
	>5 year	81,2	80,9	79,8	82,7
	Average EU´	87,1	85,3	83,6	82,4

There was a tendency that the Emission Uniformity (EU′) as measured in the field of all the dripper types deteriorated over time from an EU′ of 87,1% in the first evaluation to 82,4% in the fourth and last evaluation two years later. This is an indication that the performance is affected by clogging due to the water quality and lack of proper maintenance schedules.

Filter performance

Laboratory evaluations

The three disc filters, two sand filters and three automatic filters were intensively tested in the ARC-IAE laboratory under controlled conditions. Friction loss tests, filtration capacity tests and other performance tests like filtration efficiency, backwash efficiency; the efficiency of different cleaning operations on sand filters and the difference between the different types of discs, were the focus points of the tests.

In the lab evaluations, the filtration efficiency of the sand filters were 98%, the disc filters 57% and the screen filters 45%.

The backwashing management results in both the field and laboratory proof that the amount of water used during backwashing for the screen and disc filters are less than the volume usage for sand filters.

Field evaluations

Field evaluations were carried out in four seasons over two years on 29 farms in the five regions on six filter models.

In the field evaluations the Dirtiness Index (DI) of the water sources ranges from clean (DI < 1%) to very dirty (DI = 43%) and the filters managed to clean the water to a DI level of between 0,15% and 10,0%.

With the evaluation of the filters, it was proofed that the sand filters have higher filtration efficiencies than disc and screen filters. The filtration efficiency varied between 31,0% to 96,6%. On average, the filtration efficiencies of the different filters were as follows: sand filters 89%, disc filters 52% and automatic screen filters 20%.

With the backwash management testing, the sand filters used an average 1,63 m^3, the disc filters 0,37 m^3 and the screen filters 0,15 m^3 of water per backwash. However, the screen and disc filters backwash more regularly than the sand filters (to filter 1000 m^3 of water with a DI of 10%, both the screen and sand filter used 28 m^3 of backwash water and the disc filters only 4,4 m^3).
In Table 13, a comparative summary is given of the field measurements and the laboratory measurements on the different filters.

Table 13. Comparing the field test results and the laboratory test results
Tableau 13. Comparaison des résultats des tests de terrain et les résultats des tests de laboratoire

Filter	Dirtiness Index	Filtration efficiency (%)		Comments on reasons why field values differ from lab values
		Field	Lab	
AS	0 – 5	87	99	Too high pressures over field filters.
	5 – 10	83	99	
	10 – 15	90	99	
	15 – 20	87	99	
BC	0 – 5	33	5	Filter operated at a lower pressure than prescribed. Backwash do not clean element completely. Element largely clogged
	5 – 10	–	18	
	10 – 15	–	28	
	15 – 20	–	35	
CC	0 – 5	75	55	Manufacturer's fineness rating might differ from the rating it was tested against.
	5 – 10	88	72	
	10 – 15	85	76	
	15 – 20	–	76	
DS	0 – 5	>90	98	Good correlation because the field tests were stopped out of practical considerations before the actual readings could be taken.
	5 – 10	>90	98	
	10 – 15	>90	98	
	15 – 20	94	98	
ED	0 – 5	73	63	Good correlation seeing that this is a disc filter
	5 – 10	66	77	
	10 – 15	–	80	
	15 – 20	86	80	
FD	0 – 5	26	41	Good correlation seeing that this is a disc filter.
	5 – 10	38	37	
	10 – 15	25	39	
	15 – 20	–	41	

CONCLUSION

Drip irrigation is considered as the most efficient irrigation system, but through this research and proof from literature, it was found that this system can also be inefficient as a result of water quality, mismanagement and maintenance problems.

The new drippers coefficient of variation (CV_q) varied from an excellent 2,1% to a good 4,2% with an average of 3,12%. The pressure compensated drippers' average CV_q was 3,45% and that of the regular drippers a better 2,63%.

There was a tendency that the Emission Uniformity (EU′) as measured in the field of all the dripper types deteriorated over time from an EU′ of 87,1% in the first evaluation to 82,4% in the fourth and last evaluation two years later. This is an

indication that the performance is affected by clogging due to the water quality and lack of proper maintenance schedules.
Dripper lines with regular type emitters showed a general tendency of reduced average discharge due to partial or total clogging of emitters while drip lines with pressure compensated emitters showed a general tendency of increased discharge, due to foreign objects that got stuck between the compensating membrane and the labyrinth, or the compensating membrane losing its elasticity over time due to chemicals and the water quality. If the outlier values of CV_q are disregarded due to severely damaged drippers and heavily soiled dripper lines, the average discharge variation CV_qin the first year was a fair 6,5% for all the drip lines with a variation of 3,0% up to 21,3% for the individual drip lines. In the second year, the average discharge variation CV_q was a poor 8,2% with a variation of 2,7% up to 22,2% for the individual drip lines. This confirms the deterioration of the drippers over time and the importance of proper preventative maintenance.

With regard to the statistical uniformity discharge coefficient (U_s), the Ram PC met the requirements in 84% of the cases, the Drip-In Regular in 58% of the cases and the Agridrip PC in only 50% of the cases. For all three dripper types, no significant conclusion could be reached that the age of the pipe played a role in the degree of clogging. However, it was evident that incorrect or no maintenance of the drip systems contributed in most cases to the decreased performance.

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