DRIP IRRIGATION AS AN EFFICIENT WATER SAVING PRACTICE

FB Reinders, ARC- Institute for Agricultural Engineering
GR Backeberg, Water Research Commission,
South Africa

DRIP IRRIGATION AS AN EFFICIENT WATER SAVING PRACTICE

FB Reinders, ARC- Institute for Agricultural Engineering, reindersf@arc.agric.za
GR Backeberg, Water Research Commission, gerhardb@wrc.org.za
South Africa

ICID2015
26th ERC & 66th IEC

Introduction

Drip irrigation is considered as one of the most efficient irrigation systems but it should be management and maintained properly to keep it to perform at its best to enhance crop growth and water productivity.

Performance testing of different types and ages of drippers under different water quality conditions under typical farming conditions was carried out.

Agriplas's Drip-In Regular and Agridrip Pressure Compensated and Netafim's Ram Pressure Compensated drippers were selected, as they were the most commonly used drippers for surface drip in South Africa.

Drippers that were tested:
Agriplas
- Drip-In Regular
- Agridrip Pressure Compensated

Netafim
- Ram Pressure Compensated

Research was carried out by the ARC-Institute for Agricultural Engineering (ARC-IAE), South Africa on two drip irrigation companies' drip irrigation equipment to determine the performance of the individual drippers. Evaluations were carried out on new drippers under controlled conditions in a laboratory and it was complimented by testing of installed drippers under farming conditions.

Laboratory testing of drippers

Laboratory tests on drippers

The new drip lines with emitters were tested in the laboratory for average discharge ($\bar{q}$) and for the manufacturing coefficient of discharge variation (CV_q).

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

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

$$CV_q = \frac{S_q}{\bar{q}} \times 100$$

Where
q - 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 emitters; and
CV_q - coefficient of variation of discharge rate of the emitters (%).

Classification	Criteria for CV_q ASAE EP 405.1 (1997)	Classification
Excellent	<5	Excellent
Average	5 – 7	Good
Marginal	7 – 11	Fair
Poor	11 – 15	Marginal
Unacceptable	>15	Poor

NEW EMITTER TEST RESULTS		
Dripper tested	Dripper CV_q (%)	Average q (ℓ/h)
Super Typhoon	2,1	1,7
Drip-In Light	4,2	2,2
Ram 17L	3,1	1,6
DIS PC Lite	4,4	2,3

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 and CV_q, the statistical discharge uniformity (Us) were also calculated as shown as equation:

$$U_s = 100 - CV_q$$

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

A Us 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:

$$EU' = 100\frac{q'_{lq}}{\bar{q}}$$

Where: EU' = field emission uniformity (%);
q'_{lq} = Measured mean of lowest ¼ of emitter discharge (ℓ/h); and
$\bar{q}$ = Measured mean emitter discharge (ℓ/h).

Comparison between U_s and EU for design purposes (ASAE EP 458, 1997)		
Classification	U_s (%)	EU (%)
Excellent	95 – 100	94 – 100
Good	85 – 95	81 – 87
Acceptable	75 – 85	68 – 75
Poor	65 – 75	56 – 62
Unacceptable	<65	<50

Field evaluation of drippers

Field evaluation results								
Site	EU %	EU_a %	Us %	CV_q %	q_{max}	q_{min}	q_{avg}	CV %
[illegible]	80,9	88,1	90,9	9,1	1,3	1,0	1,1	28
[illegible]	81,3	88,6	89,8	10,2	2,0	1,5	1,6	79
[illegible]	83,8	89,0	83,1	16,9	1,9	1,5	1,8	48
[illegible]	61,8	61,6	57,2	42,8	2,9	0	1,8	286

Conclusion

In the laboratory the new regular emitters' average coefficient of variation (CV_q) was an excellent 2,2% and the pressure compensated emitters' average CV_q was a good 3,2%.

With the farm site evaluations the coefficient (CV) varied from a marginal 9,1% to a poor 42,8%. The emission uniformity (EUa) varied from a good 89,7% to an unacceptable 61,8%.

If drip irrigation systems are management and maintained properly to keep it to perform at its best to enhance crop growth and water productivity it is considered as one of the most efficient irrigation systems.

References

F B Reinders, E Grové, H Benadé, I van der Stoep, A S van Niekerk. Technical aspects and cost estimating procedures of surface and subsurface drip irrigation systems. Water Research Commission, 2012. WRC Report No. TT528/12. ISBN No. 978-1-4312-0274-6.

Good news

- "Drip irrigation for South African sugarcane farmers, which could increase yields by as much as 40%, can soon become a reality.“

- ". . . the drip nozzle can save up to 80 percent in water consumption when compared with conventional overhead sprayers."

Advantages of drip

- Sophisticated technology
- Maximum production per mega litre of water
- Increased crop yields and profits
- Improved quality of production
- Less fertilizer and weed control costs
- Environmentally responsible, with reduced leaching and run-off
- Labour saving
- Application of small amounts of water more frequent

Bad news

- *"Precisely the same amount of water can be wasted with drip irrigation as with the other systems, if it is not managed correctly."*

- *"There are many questions to answer and much information to gather before choosing a system – otherwise it could lose your money".*

- *"Many farmers still believe that they have water to spare, then an irrigation system is a must and that it will automatically profits – nothing could be further from the truth."*

Disadvantages of drip

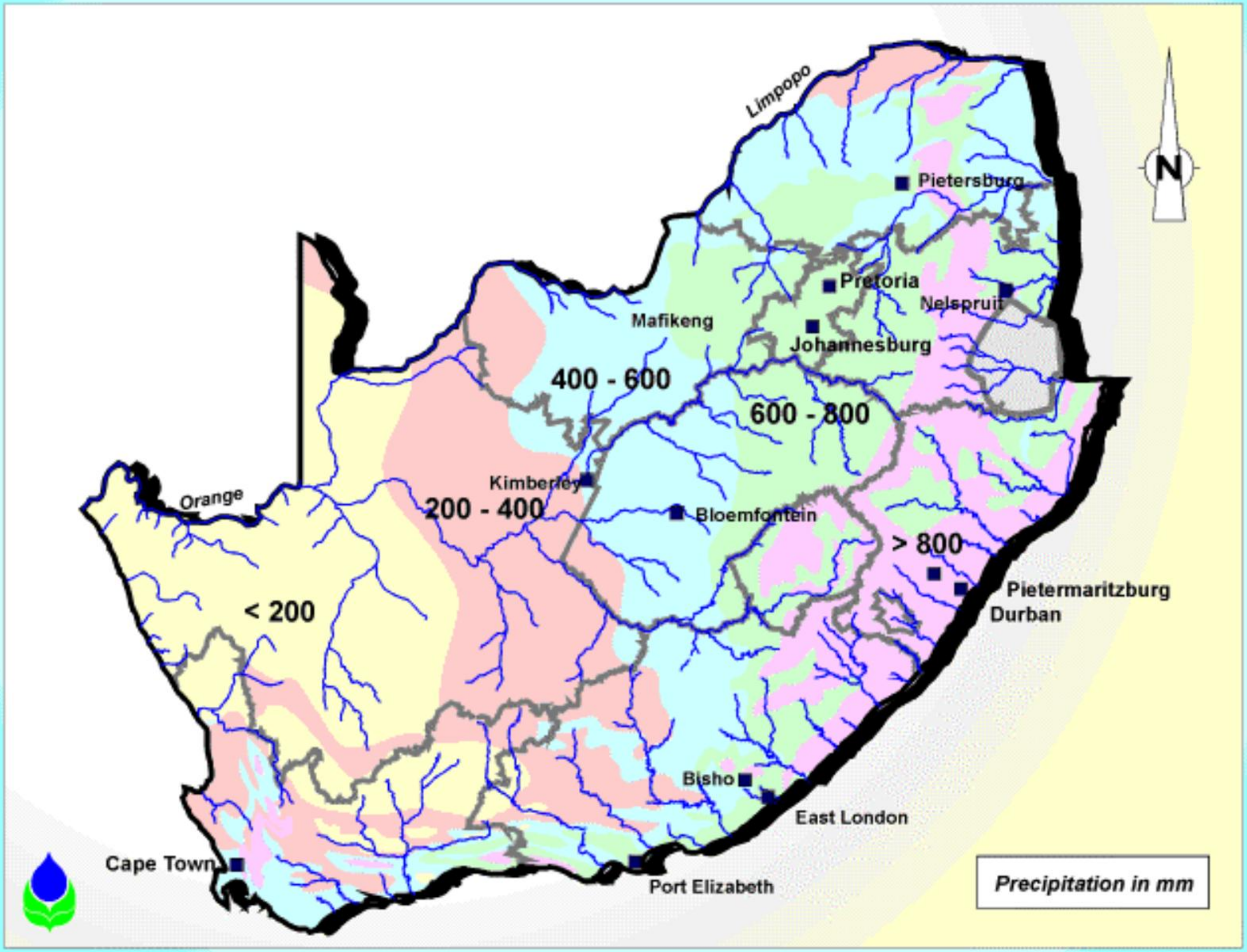
- Clogging
- Root intrusion
- Limited beneficial use of rain
- High investment cost
- Soil dependent

Looking from a performance perspective!

Background

- South Africa is a dry country.
- Many farmers invest in drip.
- Currently 150 000 ha surface drip and 10 000 ha sub-surface drip in South Africa out of a total of 1 500 000 ha.
- Proof in literature that drip can be in-efficient.

Mean Annual Precipitation

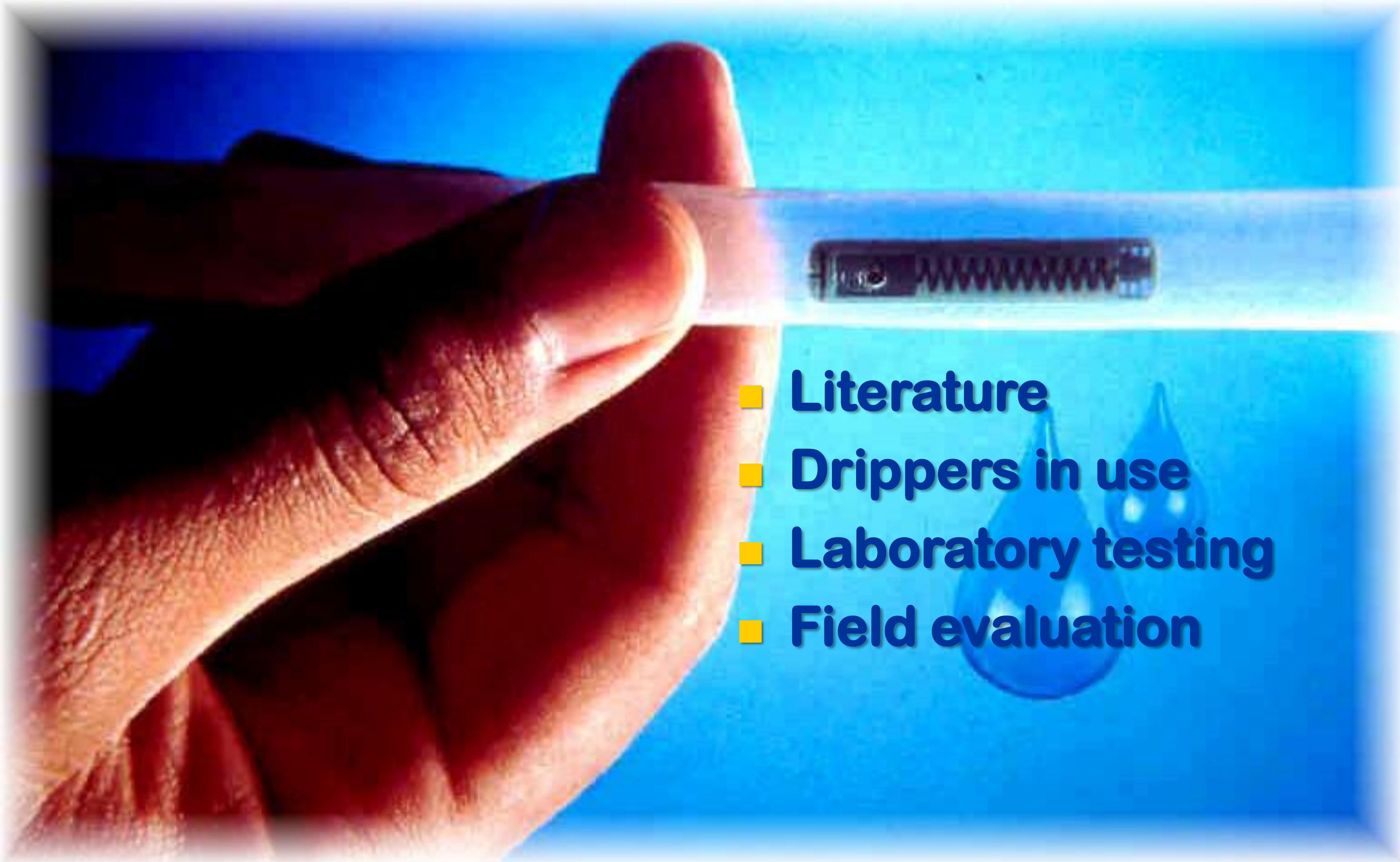


Understanding the operational principles of drip irrigation

- **Surface drip**

The performance of different types and ages of drippers under different water quality conditions under typical farming conditions.

By investigating the following…



- Literature
- Drippers in use
- Laboratory testing
- Field evaluation

Factors which influence the performance

- Water quality
- Water treatment methods
- Inherent factors
- Filtration
- System maintenance
- Design

Water quality

Factors which influence the performance:

- Physical
- Chemical
- Biological
- Fertilizers
- Oils and lubricants

Emitter type

Factors which influence the performance:

- Discharge versus pressure
- Flow path type
- Manufacturing uniformity
- Discharge versus temperature
- Friction losses
- Sensitivity to clogging
- Root intrusion
- Other factors

Filtering

Factors which influence the performance:

- Pre-filtering
- Filter types
- Selection of filter type
- Selection of filter size
- Maintenance schedule

System maintenance

Factors which influence the performance:

- Flushing of system
- Flushing of laterals
- Evaluation of the dripper discharge
- Cleaning of drippers

Design

Factors which influence the performance:

- Flow variation
- Manufacturing
- Emission uniformity

Laboratory testing of drippers

- Discharge and coefficient of discharge variation
  - New pipes
  - Pipes recovered from the field

Test according to ISO / TC 23 / SC 18 N 89

Dripper discharge test bench

Calculations

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

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

$$CV_q = \frac{S_q}{\bar{q}} \times 100$$

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

CV_q = coefficient of variation of discharge of the emitters.

Criteria for CV

CRITERIA FOR CV_Q (%) OF "POINT-SOURCE" DRIPPERS				
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

Calculations

$$Us = 100 - CVq$$

$$EU' = 100 \frac{q'_{min}}{\bar{q}}$$

Where U_s = statistical uniformity of emitter discharge rate (%);

EU´ = field emission uniformity (%);

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

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

Criteria for EU

COMPARISON BETWEEN U_S AND EU FOR DESIGN PURPOSES		
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

Drippers

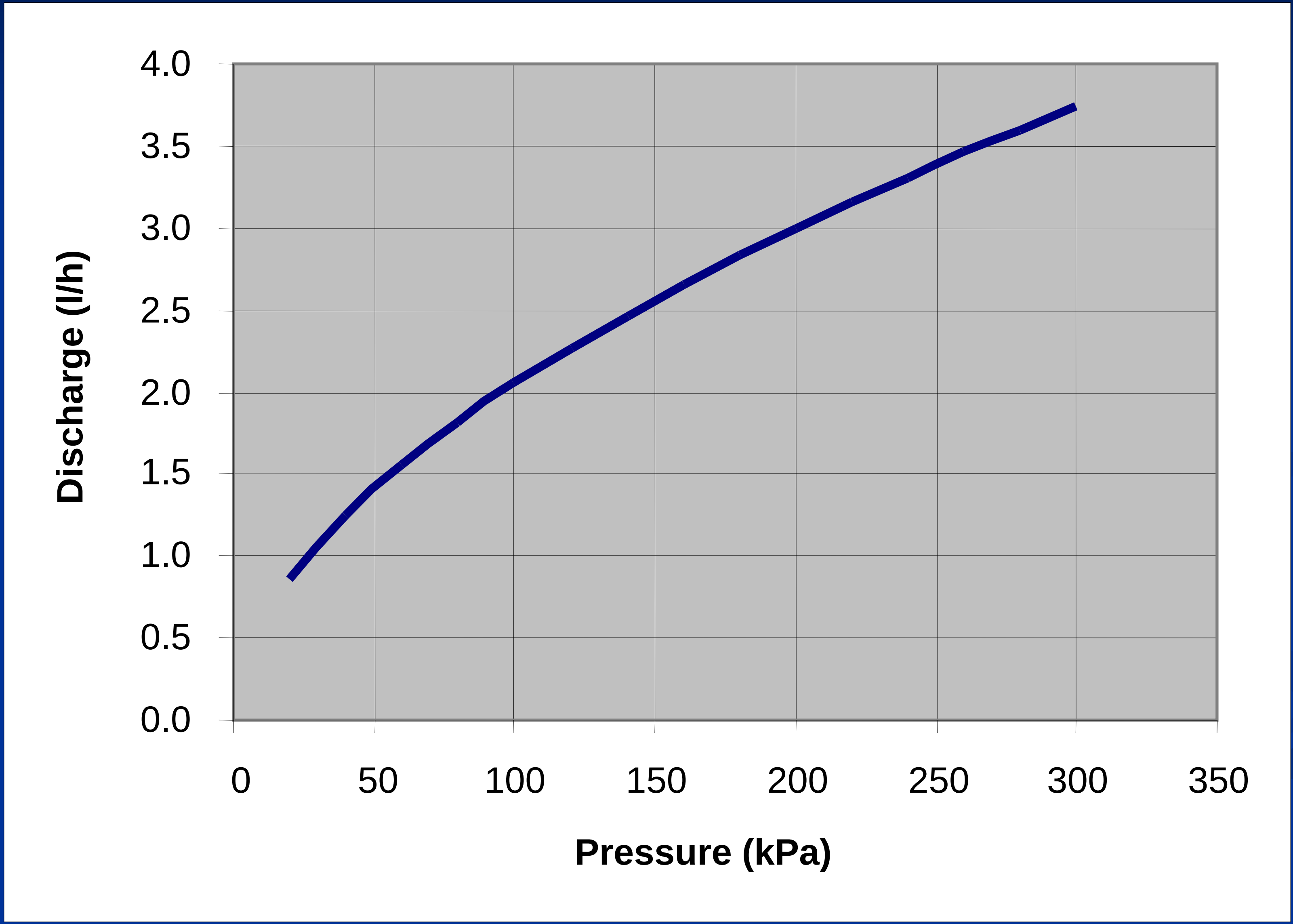
- Agriplas
  - Drip-In Regular
  - Agridrip Pressure Compensated
- Netafim
  - Ram Pressure Compensated

Agriplas dripper

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

Flow-path: Labyrinth
Outlets: 2 of 2 mm diameter
Construction operating pressure: Regular: Maximum 250 kPa, minimum not applicable, PC: Maximum 350 kPa, minimum 60 kPa. The pressure compensation process is achieved by a silicone membrane, which controls the emitter's labyrinth length that alters from a minimum length of 40 mm to a maximum length of 250 mm when pressure changes occur within the drip lateral.
Nominal discharge: This is not the measured actual discharge, but the descriptive discharge.

Regular dripper

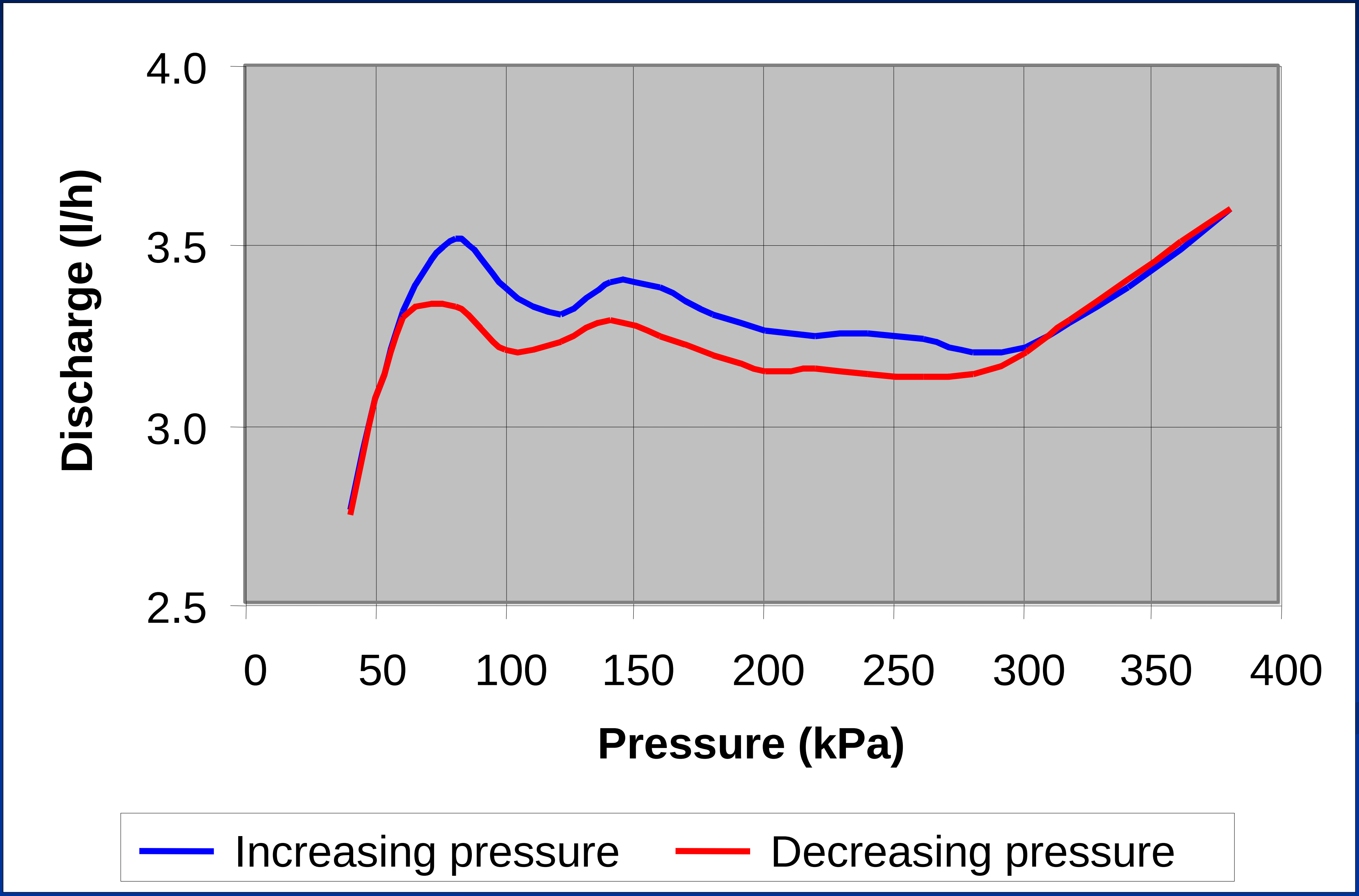


Netafim dripper

PARTICULARS OF NETAFIM RAM PRESSURE COMPENSATING (PC) EMITTERS						
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, turbo net 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	

Flow-path: Turbo net flow-path
Outlets: 1
Construction material: Polyethylene
Permissible operating pressures: 30 kPa till burst pressure of pipe. Pressure compensation: 30 kPa – 400 kPa.
All tests are performed on PC drippers with GPDM membranes.
Nominal discharge: This is not the measured actual discharge, but the descriptive discharge.

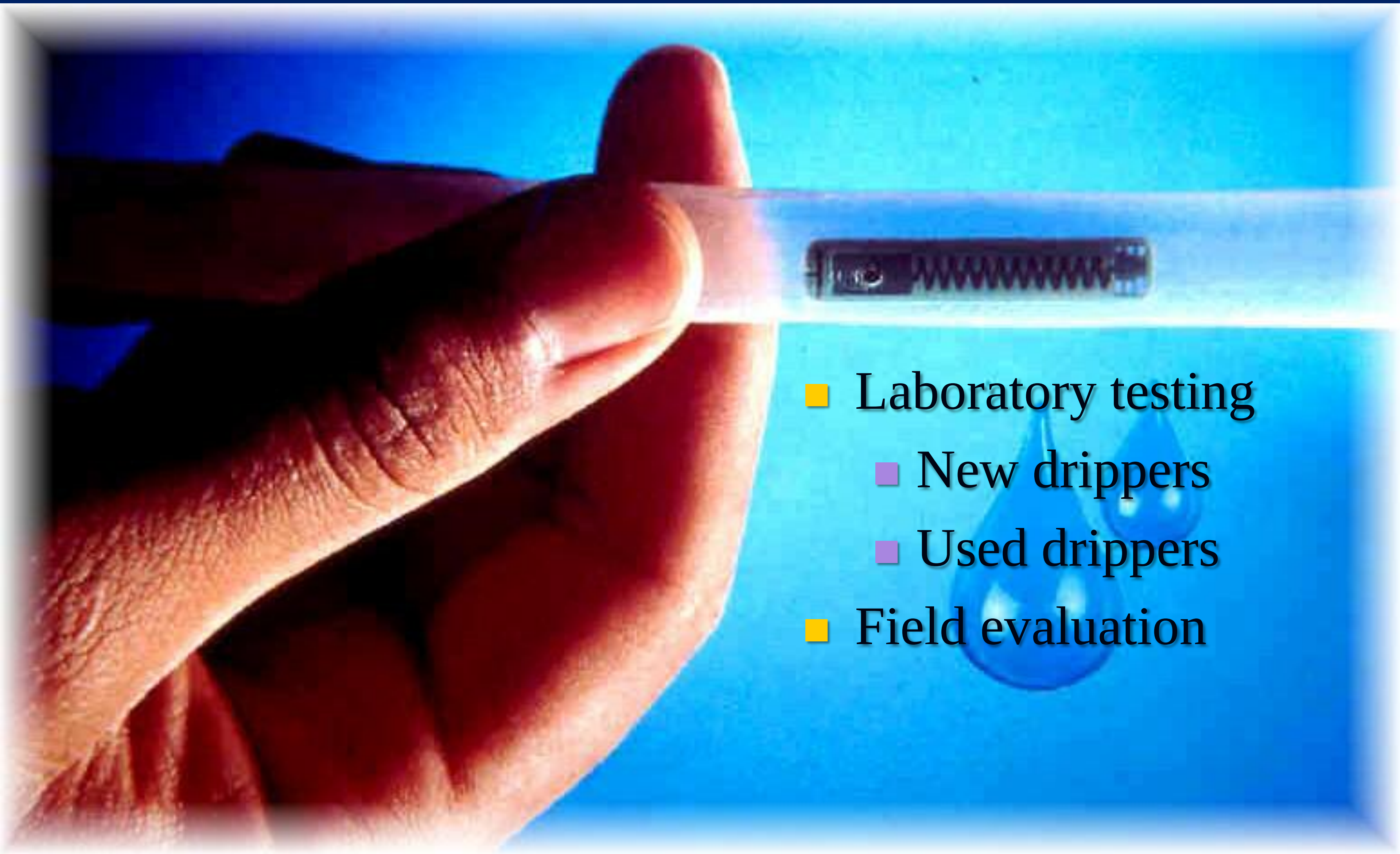
Pressure compensated dripper



Field evaluation of drip systems

- 42 drip systems in six catchment area
- Discharge and coefficient of discharge
- Test according to ASAE EP 458

Results



- Laboratory testing
  - New drippers
  - Used drippers
- Field evaluation

Summary of the CV for new and used drippers

SUMMARY OF THE AVERAGE COEFFICIENT OF VARIATION (CV_Q) OF THE NEW AND USED DRIP LINE			
Emitter	New CV_q (%)	Used Year 1 CV_q (%)	Used Year 2 CV_q (%)
Drip-In 2 ℓ/h, 12 mm	2,1	4,9	-
Drip-In 4 ℓ/h, 12 mm	3,8	5,3	10,4
Drip-In 2 ℓ/h, 16 mm	2,4	7,2	8,2
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

Laboratory testing of used drippers

PERCENTAGES OF DRIP LINES WITH EMITTER DISCHARGES DEVIATING FROM THE AVERAGE DISCHARGE OF NEW EMITTERS						
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
Agriplas Agridrip (Pressure compensating)	0	0	0	0	100	100
Netafim Ram (Pressure compensating)	16	6	21	12	63	82

Field evaluation results

Specific sites results								
Site	EU %	Eu_a %	Us %	CV_q %	q_{max}	q_{min}	q_{ave}	FV %
Inyoni	90,9	89,1	90,9	9,1	1,3	1,0	1,1	20
Savan	81,3	80,6	83,3	16,2	2,0	1,3	1,6	70
Simu1	93,8	89,0	83,1	16,9	1,9	1,5	1,6	40
Simu2	61,6	61,6	57,2	42,8	2,9	0	1,8	290

Field evaluation

THE AVERAGE EU´ VALUES PER DRIPPER TYPE PER AGE GROUP UNDER FIELD CONDITIONS IN PERCENTAGE					
Dripper type	Age	Date			
		Year 0	Year 1 Q1	Year 1 Q2	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

Conclusion and summary

- Summary
- Recommendations
- Conclusion

Conclusion and summary

PERFORMANCE OF DRIPPERS					
	CV %		Us %	EU %	
	New	Used	> 80%	Year 1	Year 2
Ram PC	3,3	6,6	84	89,2	86,5
Agridrip	3,8	9,1	50	89,5	75,2
Drip-In Regular	2,6	5,7	58	83,8	81,8
Average	3,2	7,1	64	87,5	81,2

Operation and maintenance

MINIMUM MAINTENANCE SCHEDULE REQUIREMENTS FOR DRIP IRRIGATION SYSTEMS			
Monitor	Every cycle	Monthly	Yearly
Inspect system for leaks and calcium carbonate precipitation	✓		
Check pressure difference across filters and system operating pressure	✓		
Adjust filter back flush cycle		✓	
Flush laterals (depending on water quality)		✓	
Clean filters thoroughly		✓	
Service air valves and pressure control valves			✓
Check hydraulic and electrical connectors			✓
Check hydraulic valves and filters to inspect moving parts			✓
Replace sand of sand filters			✓
Chlorine treatment (depending on water quality and application method)			✓
Take water samples at end of the laterals and evaluate changes in water quality			✓

GREENDRUM TECHNOLOGY TO CLEAN DRIPPERLINES

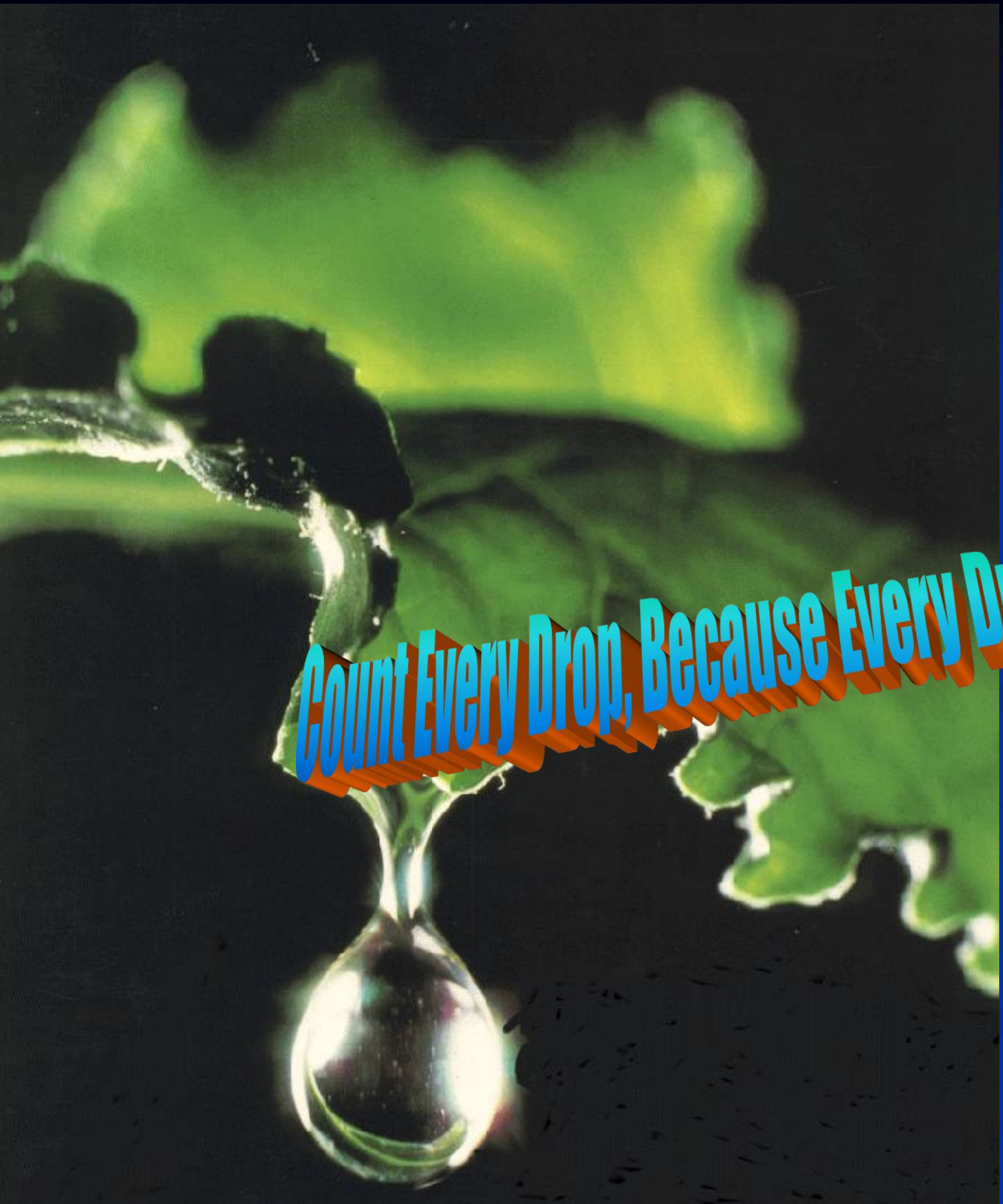
Greendrum technology uses ultra-sonic sound in a small body of water to effectively and quickly clean drip irrigation lines and pipes with ease. It is environmentally friendly and does not use any chemicals.

What the ultrasonic sound does is create millions of tiny vacuum bubbles on every micro surface of the dripline that will then implode in the pipe and cause shockwaves that completely strip all impurities in seconds.

A technical evaluation was done by the Agricultural Research Council-Institute for Agricultural Engineering in South Africa on the Greendrum dripline cleaning machine and the results showed that there was a 73% change in the Coefficient of variation (CV) of the dripper line from a bad CV of 10,57% to an excellent CV of 2,85%

Conclusion

Drip irrigation's success depends on the correct choice, optimal design and proper operation and maintenance practices to effectively ensure that availablewater resources are utilised effectively.



Count Every Drop, Because Every Drop Counts