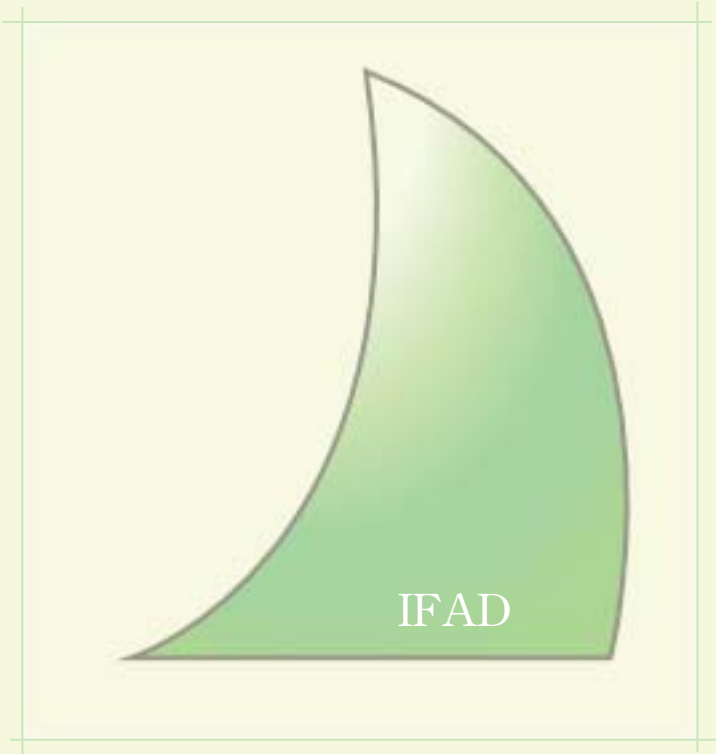
20 August 2009

The

Dutyion™ Root Hydration System



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dRHS™ - High efficiency & salted water irrigation technology

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- The information provided in this document corresponds to our knowledge on the subject at the date of inclusion. The information may be subject to revision as new knowledge and data become available. The data fall within the normal range of product or system properties and relate only to the specific reference material or system, performing in the specific reference environment. For any given installation, a wide number of variants need to be considered and each system needs to be designed by a competent person, taking into consideration the key influencing variables. Data does not, nor is intended to substitute for any testing which you may need to conduct to determine for yourself the suitability of the material or system

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Dutyion™ Root Hydration System

- The Dutyion™ Root Hydration System - dRHS™ - is a proprietary subsurface Irrigation Technology which relies on Plant Demand to actively provide the required amount of water
- The dRHS™ uses targeted water delivery and is highly water efficient
- The system uses Dutyion™ SmartPipe™ technology which allows water to pass through its walls by a process of 'Phase Change Permeation™' - 'PCP™' - Water is only delivered when the plant demand exceeds free moisture in the soil. The water is delivered as water vapour, avoiding over saturation of the soil and roots
- **When used with saline or brackish water, most or all of the salt is retained within the SmartPipe™ enabling the use of brackish or salted water to successfully irrigate crops over sustained periods without the need for pre cleaning or desalinating the water first**

Radishes & Tomatoes
These plants were grown in early field trials using membrane material

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- *Worldwide, there are in excess of 1 billion acres of land with saline aquifers*
- *Around 14mm acres of land a year become unproductive due to heightened salinity - some of this damage caused by irrigation itself*
- *Fresh water scarcity is a Global problem which is increasing - exponentially*

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- These photographs are of a Dutyion™ Root Hydration installation in the desert in Abu Dhabi - temperatures of almost 50°c
- The deserts of the United Arab Emirates are some of the most challenging environments in the World in which to attempt to grow plants sustainably
- The small trees you see in the pictures have been sustained for nearly 18 months, watered solely with saline ground water in conjunction with the dRHS™ SmartPipe™

- Unwatered control plants died within a very short time of being planted - a necessary part of trialling to ensure there were no factors which might allow the trees to survive without irrigation

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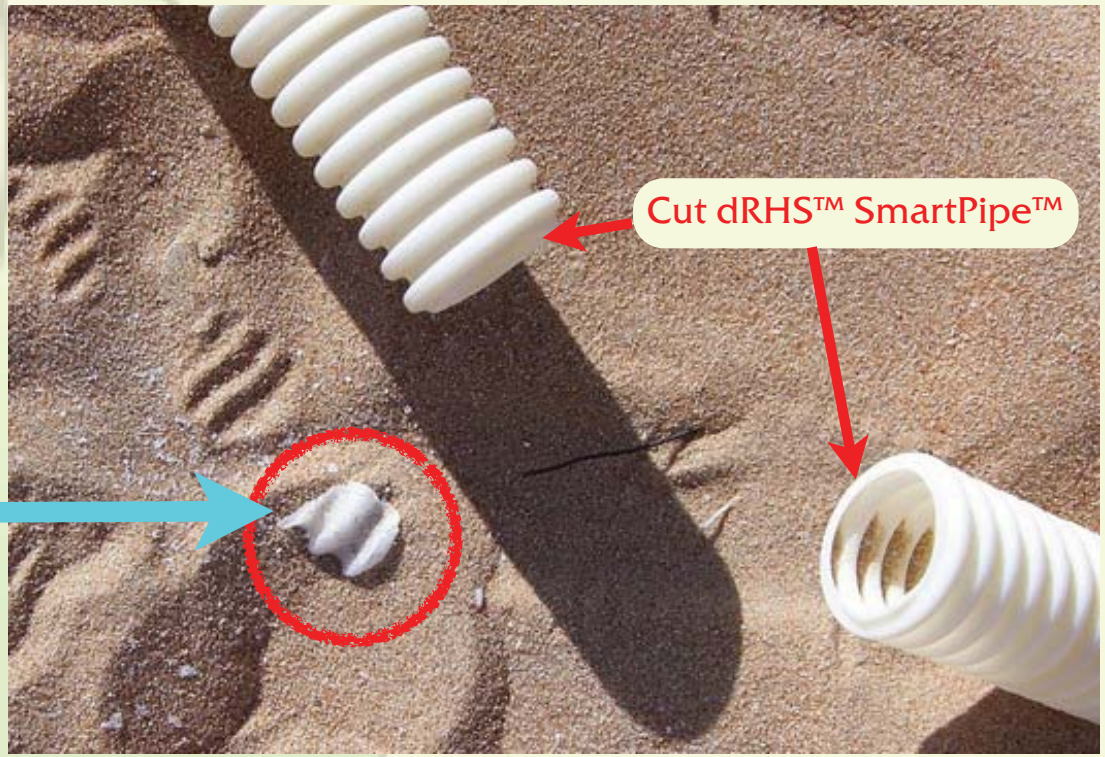
- In a static saline water irrigation test, the ability of the dRHS™ SmartPipe™ can clearly be seen :

- This pipe had been successfully irrigating trees in Abu Dhabi

Retained salt crystal formed on the inside of the Irrigation pipe



- In a commercial installation, the concentrations of salt are routinely flushed - a task which can be automated

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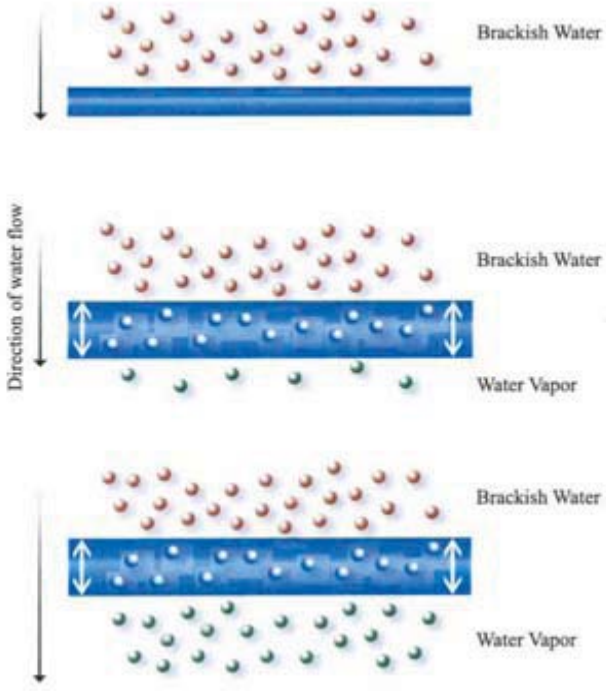
How dRHS™ SmartPipe™ Works



1. Water is absorbed and the membrane swells in volume
2. Pure water vapor is released from the dry side of membrane and will be used as needed
3. Equilibrium is reached if water vapor is not removed from the dry side

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Commonly available 'clean water' irrigation types

- Surface Drip Irrigation
  - This technology, installed on the surface, uses emitters or tape with holes in it - it can deliver both fresh water as well as fertigation - herbicides, fungicides, fertilisers
- Subsurface Drip Irrigation
  - is positioned in the ground at a pre determined depth, it uses emitters or tape with holes in it to irrigate, more efficiently than surface drip irrigation and it too can deliver fertigation into the ground - some systems are extremely high tec, even using space satellites to determine watering schedules
- Sprinkler / Centre Pivot / Water Cannon/Gun Irrigation
  - This is used to replicate Rain on crops. It has a more limited ability to target plants and is generally considered to be inefficient - although it is satisfactory and cheap, where water is freely available - it can be used as a fertigation delivery method although this is somewhat 'scattergun' - it also crosses over into flood irrigation
- Flood Irrigation
  - The method here is usually diverting the flow of a body of water to briefly literally flood the ground until it becomes saturated. Sometimes centre pivot irrigators and water cannons are used to achieve the required flooding. This type of irrigation is considered to be inefficient but again, satisfactory where cheap water is available

Options for Irrigating where only Saline / Brackish water is available

- **Direct Watering with Saline / Brackish Water**
  - This may be acceptable for short term irrigation of salt tolerant plants but, long term salt build up in land renders the land unusable in a very short time
- **Conventional irrigation with desalinated water**
  - This requires substantial investment - hundreds of thousands of $'s for even a modest desalination plant - in addition to the cost of the irrigation system - it also requires substantial on going cost for personnel, running and maintenance costs of the desalination plant, over and above the costs of running the irrigation system. It is frequently impractical and or not commercially viable, especially for smaller plots of land, inland and or remote locations

This dRHS™ Irrigation grass trial was conducted in Spain in 2008

The trial plot was set out under open air cover, the supply tank can be seen in the top right of the picture - the dRHS™ pipe installed in the planter square required flushing at 2 monthly intervals - the drain can be seen at the bottom right - the growing medium was local naturally sandy soil

Commonly available forms of desalination

- Distillation and Multi Stage Flash Distillation
  - These technologies work by heating salted or polluted water to cause evaporation, the evaporate being condensed back to pure liquid water - in a multi stage flash process the pressure is lowered as well as the water heated so that the water 'flashes' into vapour - which is cooled to cause rapid condensation -
- Reverse Osmosis
  - In this technology, salted or polluted water is pumped at very high pressure through a semi permeable membrane which allows water but not salts to pass through it. This requires substantial investment - hundreds of thousands of $'s for even a modest desalination plant - it also involves substantial on going cost for personnel, running and maintenance costs of the desalination plant itself. It is frequently impractical and or not commercially viable, especially for smaller plots of land, inland and or remote locations to have desalination plants
  - The typical cost of fresh water produced using desalination technology is between $0.6 / 1000l in the most modern and efficient systems to $2.00 / 1000l in the less efficient installations

Desalination & Power

- Typically it takes approximately 3kWh to desalinate each 1000 litres of salted water
- This power can be provided by:
  - Conventional Electricity supply
  - Co-operation projects - ie building a desalination plant in conjunction with a nuclear, coal, gas or oil fired power station. Desalinated water is partially used for the steam part of the generation cycle the remainder available for commercial water supply
  - Solar Projects - Concentrated Solar Power - CSP - and Photo Voltaic Panels - smaller desalination systems, powered by solar energy can be used to power desalination plants
- An important note here is that conventional power generation is itself limited by the amount of available fresh water - virtually all electricity generation relies on copious quantities of fresh water for steam to drive the generators - power station development projects have been refused approval in the USA because of the lack of available fresh water

Global Challenges for Desalination Plants

- Environmental concerns around power consumption & CO^2 emission - including the amount of fresh water required by power generation itself
- The highly saline brine waste from desalination plants is a source of local environmental damage - it can lead to areas of reduced or even extinguished aquatic life and or increased salinity in aquifers and wells - the dRHS™ will raise the salinity level of the flushing water but the salinity level is significantly lower than desalination brine and the impact is therefore significantly less and more easily dispersed
- Water is often returned from desalination plants at high temperature - especially from multi stage flash plants - which again damages the local aquatic life
- To achieve cost per litre advantage the desalination plants have to be on a large, high capital cost scale - they require big investment up front
- Desalination plants are built on or very near the source of saline water, which may be some distance from the point of use, especially large scale plants - this introduces pumping costs and further environmental impact damage
- Which leads on to the visual impact of a large desalination plant - the negative impact on the environment and landscape - these are heavy costs

Challenges for Conventional Irrigation

- Surface and Sub Surface Irrigation:
  - These technologies require High Quality Fresh Water - high pressure, high tec turbulent flow emitters, very fine filtering of the water and constant monitoring. Issues include water quality, blocked emitters, clogging filters and salting of the ground. These systems are highly developed but they are susceptible to evaporative losses and emitter failure
- Sprinkler Irrigation:
  - These systems require High Quality Fresh Water, high pressure, control emitters and constant control / monitoring. The principle downsides are poor efficiency, poor targeting and significant evaporative losses
- Flood Irrigation
  - This requires High Quality Fresh Water and diversion channels - it is generally inefficient in its use of precious water but it is low cost and simple. This is not considered as competition for the Dutyion™ Root Hydration System

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Choice of Irrigation Systems

Conditions	Surface Drip Irrigation	Subsurface Drip irrigation	Sprinkler System	Flood Irrigation	Dutyion™ root Hydration	Comments relating to Dutyion™ SmartPipe™
Plenty of low cost fresh water	✔	..	✔	✔	✔	
Limited low cost fresh water	..	✔	..	✘	✔	Dutyion™ has higher water efficiency due to the plant led demand resulting in lack of water losses - more crops can be grown with the same amount of water
Plenty of High cost quality fresh water	..	✔	..	✘	✔	Dutyion™ has higher water efficiency due to the plant led demand resulting in lack of water losses - more crops can be grown with the same amount of water
Limited high cost quality fresh water	..	✔	✘	✘	✔	Dutyion™ has higher water efficiency due to the plant led demand resulting in lack of water losses - more crops can be grown with the same amount of water
Brackish water only	☠	☠	☠	☠	✔	Dutyion™ has the ability to retain salts whilst allowing water vapour to enter the soil matrix to support plant growth - brackish water can be used
Saline water only	☠	☠	☠	☠	✔	Dutyion™ has the ability to retain salts whilst allowing water vapour to enter the soil matrix to support plant growth - saline water can be used

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Aside from the 'Hard' advantages - there are 'Soft' advantages of Dutyion™

Benefit of dRHS™ Irrigation Technology	Financial	Social / Environmental
Accurately and highly efficiently makes moisture available to target plants roots whilst minimising water losses	☑	☑
Enables the use of low value or no value water or the extremely efficient use of fresh water	☑	☑
It makes best use of land and resources - land which is unusable today - land stewardship is improved		☑
Minimum energy consumption / co^2 emissions when compared to pumped or desalinated water	☑	☑
Enables the regeneration of land and increases overall yieds	☑	☑
Helps in the remediation of poisoned or salted land	☑	☑

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Financial Validation

A conservative financial assessment shows how the system offers benefits in a wide range of circumstances - most particularly of course in areas where there is no viable alternative

The key first targets for the dRHS™ technology are areas of the Globe where conventional irrigation systems simply cannot operate today

- Dutyion™ has the highest value for irrigation where only brackish or saline water is available. In this case there is no currently available long term alternative for irrigation
- In other areas where fresh water may be currently available at a high cost, the efficiency of the plant led Dutyion™ Technology can make it an attractive alternative to subsurface drip irrigation

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Financial Validation - Basis of Assessment

- DTI-r has a technology which can be successfully used to irrigate with saline water without substantial salinification of land
- The technology can, in certain circumstances, use as much as 40% less water than conventional drip irrigation when operating with clean water. This may vary dramatically by application and is used as a general figure for guidance only
- dRHS™ systems are designed and installed to last for at least 3 - 5 years - the actual lifespan will depend on use and location but the theoretical useful life of a system may well be more than 10 years - DTI-r has a test system which was installed for over 5 years with no signs of any changes in performance
- As with drip irrigation systems, each installation must be custom designed to suit the relief, soild type, weather, environment and target plants - the relative benefits over conventional irrigation systems will be greater or smaller depending on the variables taken into account for every conventional irrigation installation
- Manufactured tube costs in the region of €1.30/m in small volume production, including the cost of the material - in mass production high volume this price will fall significantly
- The basic assumption is that 1m of dRHS™ tube has the ability to release between ½ to 1 ltr of water per day - depending on the environment
- The cost of desalinated water is at best $0.5/1000ltrs using a large scale highly efficient commercial plant - it is significantly more expensive for smaller installations
- The energy required to desalinate 1000 ltrs of water is around 3kW - producing 3kW of electricity emits around 2.7kg of CO^2

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In some cases there is simply no alternative to the dRHS™

Green shoots from the Abu Dhabi 2008 field trial - trees in 50°c and only saline groundwater delivered purely by the dRHS™ SmartPipe™

Striped Tomatoes grown under glass in the UK in 2008 - water delivered purely by the dRHS™ SmartPipe™

In other cases dRHS™ may be an attractive alternative

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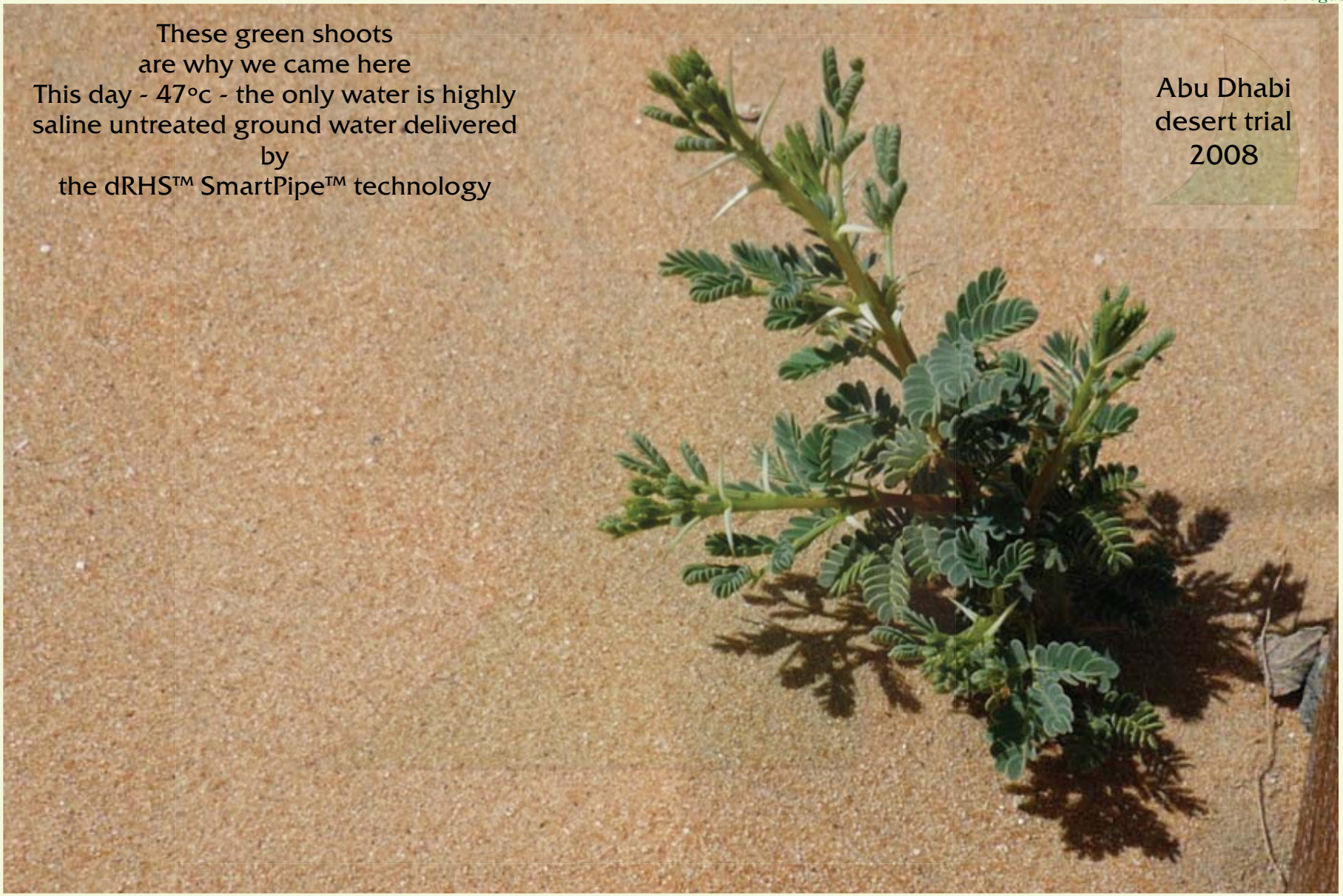
Flowers grown in 2008 using the dRHS™ irrigation technology under glass in the UK

These green shoots
are why we came here
This day - 47°c - the only water is highly saline untreated ground water delivered
by
the dRHS™ SmartPipe™ technology



Abu Dhabi
desert trial
2008

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Thank you for your time and interest in the

Dutyion™ Root Hydration System

Please contact DTI-r with any queries
or
to register your interest

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