SUBSOIL IRRIGATION SYSTEM SPS

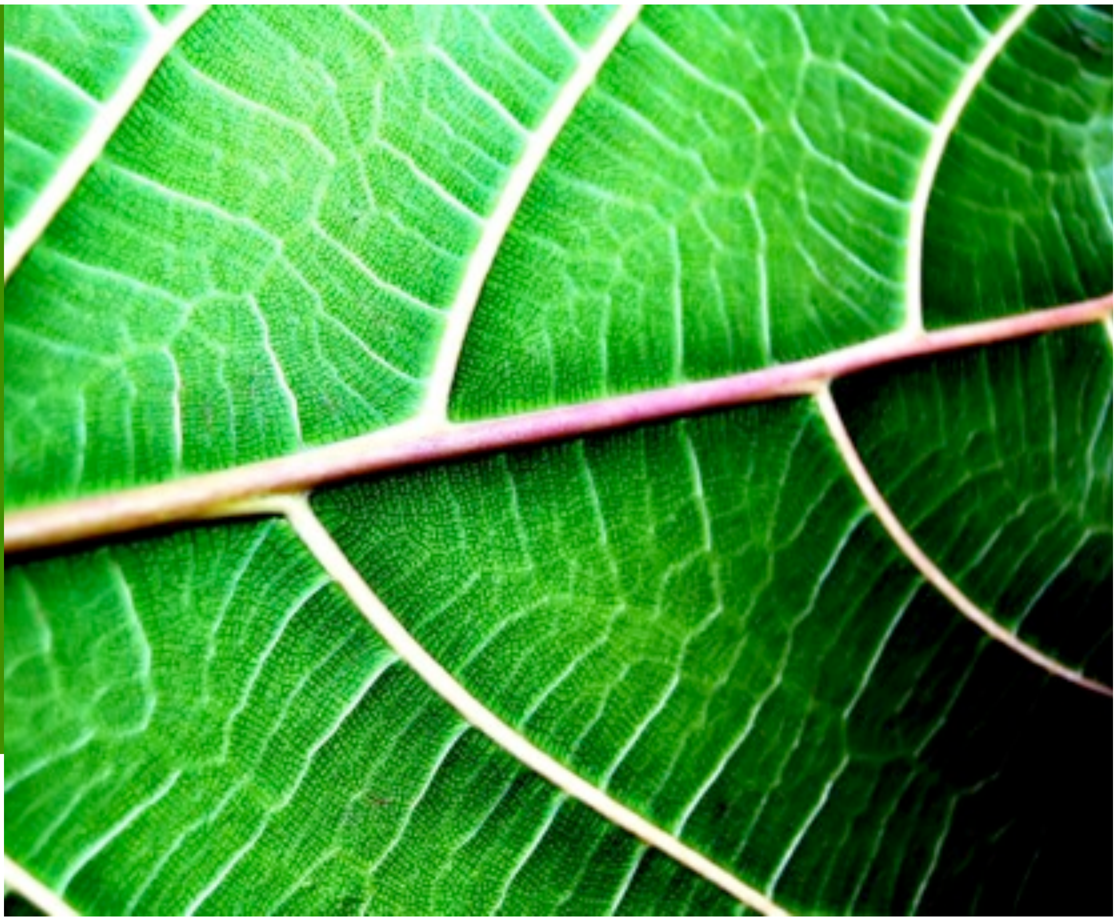
Water Innovations

in Cooperation with Technology Institute Dr. Staender

Vitality on a new level

By Sustainable Innovative Solutions International

BENEFITS



Optimal Irrigation
Maximum efficiency

- SPS System provides optimal irrigation for agricultural and horticultural products by reducing dependency on rain water

- Biological products produced with SPSS are of the highest quality, while the use of chemical fertilizers is minimized and natural liquid compost added

- Water is used efficiently with savings between 30% up to 70% (in high temperature areas) (1)

- Possible recycling of rubber after more than 20 years of usage

- If the system is used for food crops in semi-arid areas or with high air temperatures SPSS can double or even quadruple the production (figure 3)

- Temporary soil warming with residual warmth for special crops that are not winter-hard

Introduction

The SPS system falls in the scientific category of Subterranean Drip Irrigation (SDI). It was developed by Prof Staender from Munich in Germany. SPS has the potential both to revolutionize the efficiency and restore the ecology of mainstream agriculture.

The ´Nanotube` is the heart of the SPS system. It is made of non sticking smooth rubber designed to last more than 20 years and is 100% stretchable. The rubber can be recycled at the end of its life cycle.

With the system in operation, a farming community can also keep its traditional manual farming practices.

The SPS system is therefore designed to be economically, ecologically, socially and culturally sustainable.

The first cluster project around SPS was developed and designed by Professor Staender, to help farmers in dry semi-deserts of Libya and Greece grow fodder for their animals. For the families he found water in underground rivers and grew biomass for cooking, heating and building houses (figure 1).

Figure 1. C-4 reed plants with subsoil irrigation, 7 meters high (Greece, 1987)

'City-deserts' are semi arid areas where greenery is scarce. The SPS system can help saving drinking water by using stored rain water for gardens, roofs and open walls (see figure 2). It conserves energy by means of isolation, while plants produce oxygen and consume CO_2.

Figure 2. Roof greenery and facades with SPS

The SPS system applied in developing countries, especially in arid areas, must be part of an indigenous system to save water. To maximize effectiveness or help in the climatic regions where SPS is not suitable (e.g. areas with extreme water scarcity) other sustainable innovations developed by SiS and its partners can be applied.

Key Features of the SPS

1.The “Nanotube” is the key element of the SPS micro-irrigation system. It is produced from a unique synthetic rubber to which no particle will stick*.

2.The synthetic rubber has high elasticity of ca 100%. This very quality minimizes the risks of ruptures and leaking. The lifetime of the tube in wet condition is expected to be between 20 - 40 years.

3.If through some external impact a rupture takes place, the place of the rupture is visually detectable through a wet soil surface and the tube can easily be repaired.

4.Roots cannot penetrate into the tubes. The valves of 15 Micron (0.0015 mm) are smaller than hair roots of the plant. The ‘liplike valves’ open at 1.5 bar and close again as a result of lowering that pressure.

5.Operational pressure is between 1.5 and 4.5 bar. This is evenly distributed over all the valves.

6.While opening and closing for many years the tubes sustain operational pressure: no tearing of the openings will take place.

7.Each outlet releases on average 3 to 4 cubic centimeters per minute. This amount does not exceed the water uptake capacity of the soil. The water is distributed homogeneously through capillary activity (please see figure 4).

8.The distance between tubes depends on crops and local situation. It normally ranges between 30 to 70 cm (figure 8). The maximum exception is 150 cm (for maize in the United States) (2).

9.The depth of the tubes is also customized, depending on the root system of the plant and the capillary properties of the soil.

10.The plowing practices additionally determine the depth of the tubes (average 30 to 70 cm).

11.Between 10 and 20 km of Nanotube is on average required to install 1 Ha of the SPS system (figure 8).

*The exception is ‘Ferro-slime’ that can be present in some soil layers. This problem can easily be resolved either by drilling for water at deeper soil layers or by filtering it out at a storage tank before it is pumped into the SPS system

Characteristics of the SPS

Intermittent irrigation is used in order to achieve constant water supply. This does not stress the soil, because the total switch on – switch off time depends on the capillary conductivity of the soil. Precisely dosed irrigation delivers a homogenous moisture profile underneath a dry top layer of approximately 10 cm thickness (see pictures below).

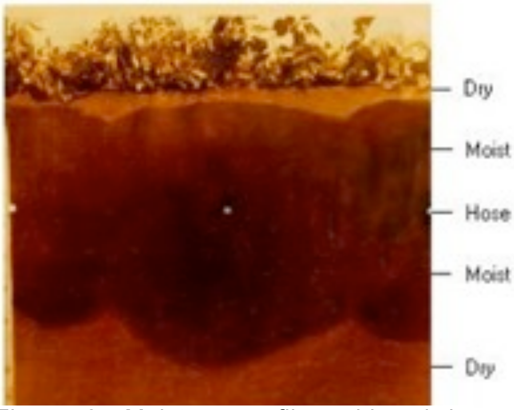


Figure 3. Moisture profile achieved by precisely dosed subsoil water supply (under field condition – behind plexiglass window)

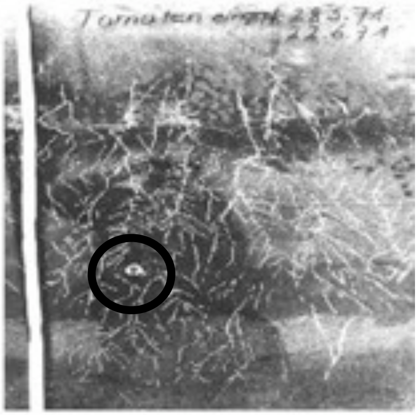


Figure 4. Formation of a homogenous root profile around one subsoil irrigation hose

Compost tea (3)**.** With SPS it is possible to administer a 'cocktail' of soil bacteria to boost the regeneration of the soil food web, which insures that healthy root system is maintained.

Hot and dry summers in western Europe nowadays are not a rare phenomenon. In the situation below two neighboring sites in Kaltenborn, eastern part of Germany, were both suffering the summer of 2006 with little water available. The farmer on the right lost all crops; the one on the left secured his crops with the SPS system.

Figures 5 and 6. Two maize cultures in 2006. It is no surprise that with SPS the condition of the maize was much better. In this situation no extra fertilization was given.

Drip Irrigation Qualities

Drip irrigation in general is suitable for fertile, semi-arid and desert areas. Farming in desert areas was originally demonstrated in Israel by Netafim (4), producer of drip irrigation since 1947. Now hundreds of scientific studies about Drip Irrigation (DI) or Subterranean Drip Irrigation (SDI) have been conducted (5).

'Free' global market. A majority of scientists and manufacturers in the 1980's were convinced that chemical fertilizers and pesticides would boost the yield of crops forever. Politicians believed that hunger could soon become a phenomenon of the past. Large arable areas were transformed into high yield 'monocrop' farming. Through overexploitation due to 'the must of quantitative competition' on the 'free' global market (not really free because of subsidized farming), we witness today the negative ecological impact on soils, water and human health at an alarming rate.

Interdependency of all life. Gottlieb was one of the creators of a scientific model for understanding dynamic interconnectivity of all living systems. Through chaos theory it is now understood scientifically that if resources of some vital aspects of the life cycle are destroyed a chain reaction of undesired events will follow.

The soil web (see figure 7) is a truly crucial aspect of human and animal life today in many regions of the world. If the food chain is destroyed this leads to massive loss of animal species that need healthy soils and healthy waters for nourishment. In profit-dominated agriculture the natural biological quality is of less importance. Quantity, fashionable forms and colors are more important than quality. The poor farmers fear loosing the crop, which leads to too many pesticides being used. Research shows that essential vitamins are increasingly lacking, health in the general population is deteriorating rapidly with a percentage of severe diseases steadily growing.

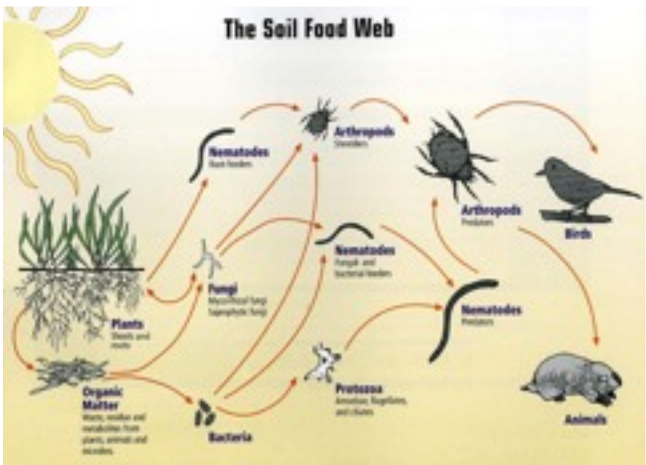


Figure 7. The Healthy Soil Web (6)

High quantity and high quality food production both in fertile and semi-arid areas can be stimulated by the SPS system. Water and biological nutrition use efficiency are the main drivers of this possibility (please see section 'protective substances').

Investments in Research and Development of SDI systems were until today, with exception of Israel, mostly done predominantly with private funds.

Increasing food shortages, water pollution and ecological disasters are now inevitably reversing the trend. Investments, branding and commercialization are offering increasingly more possibilities.

Agricultural Field with SPS

The SPS system is technically not difficult to install. If necessary, the installation can be done entirely manually with the help of animal power. This is important for situations where there are no agricultural machines available.

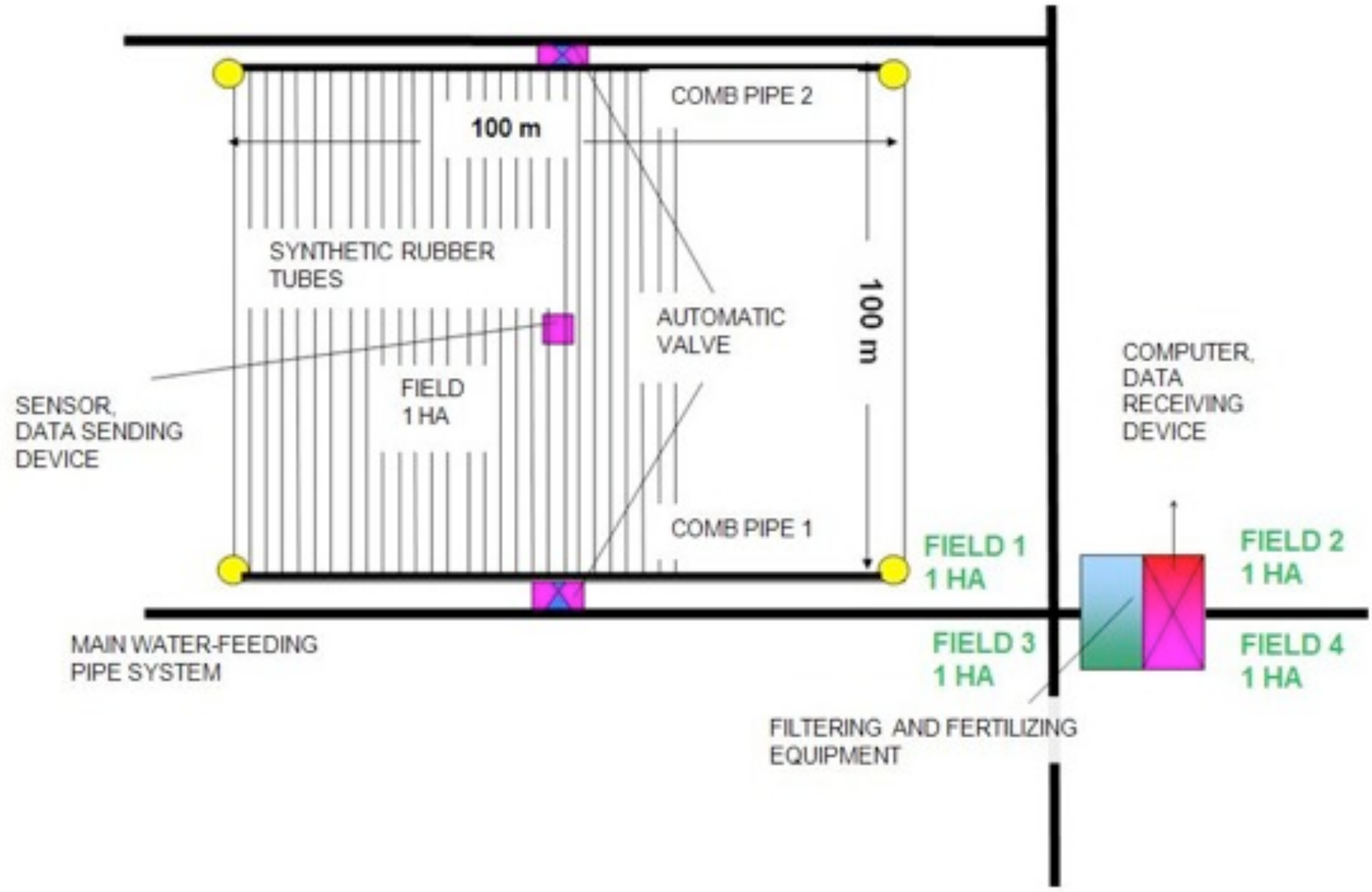


Figure 8. Schematic representation of complete SPS system installed on a field of 1 HA (can be replicated on fields 2,3,4)

1. Preparation

2. Digging trench for water-pipe

3. inserting tubes

Installation

Insertion of the Nanotubes is done by a simple knife-like plow structure that is specially developed for this purpose (please see the pictures). For large areas a bigger plow is capable of placing 1 to 4 tubes at once.

Easy installation and low labor costs of the installation process (one time only in 20 years) are also significantly lower if applied on a scale larger than 50 Ha.

4. Connecting water-pipes

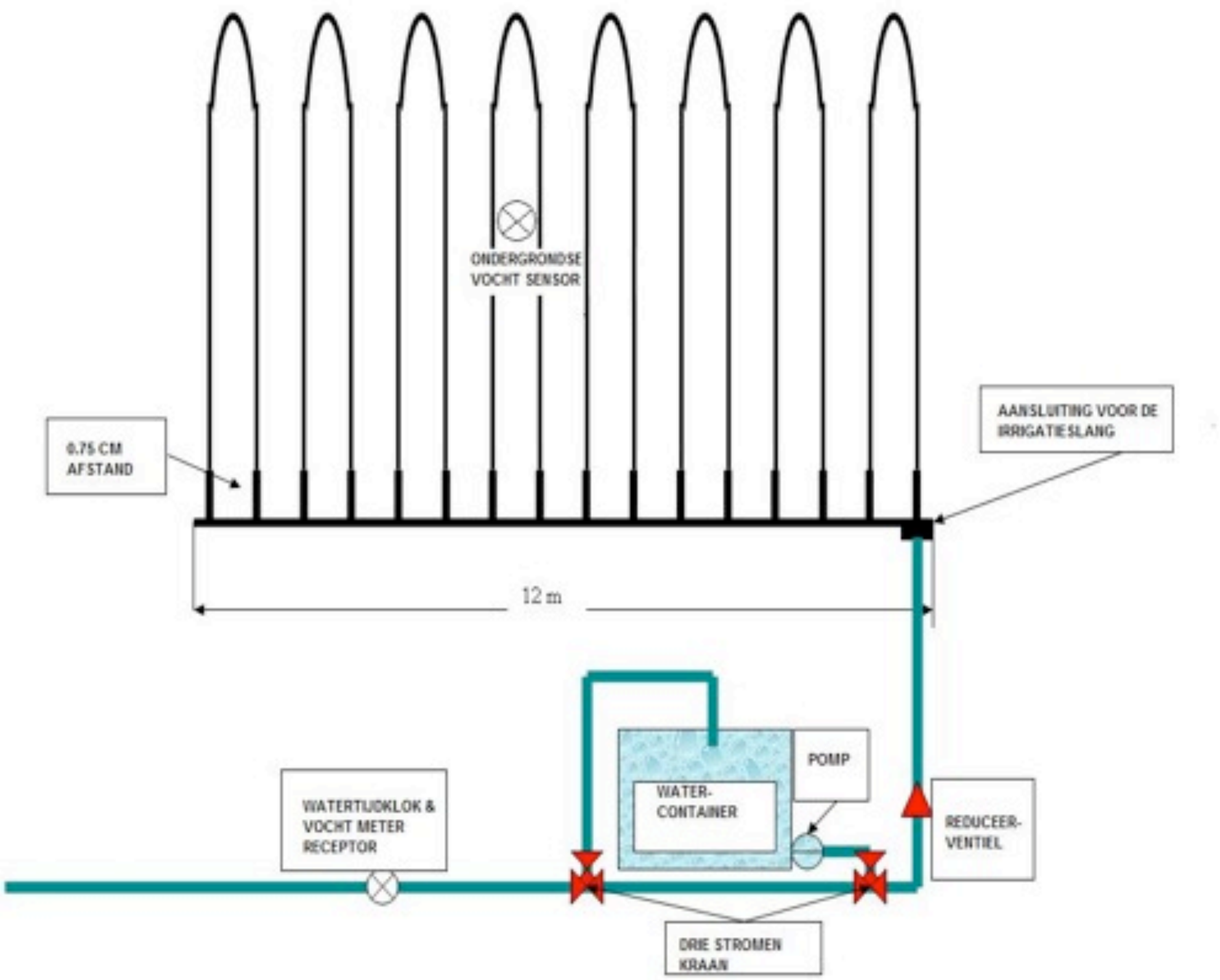
5. Machine for inserting four tubes at a time

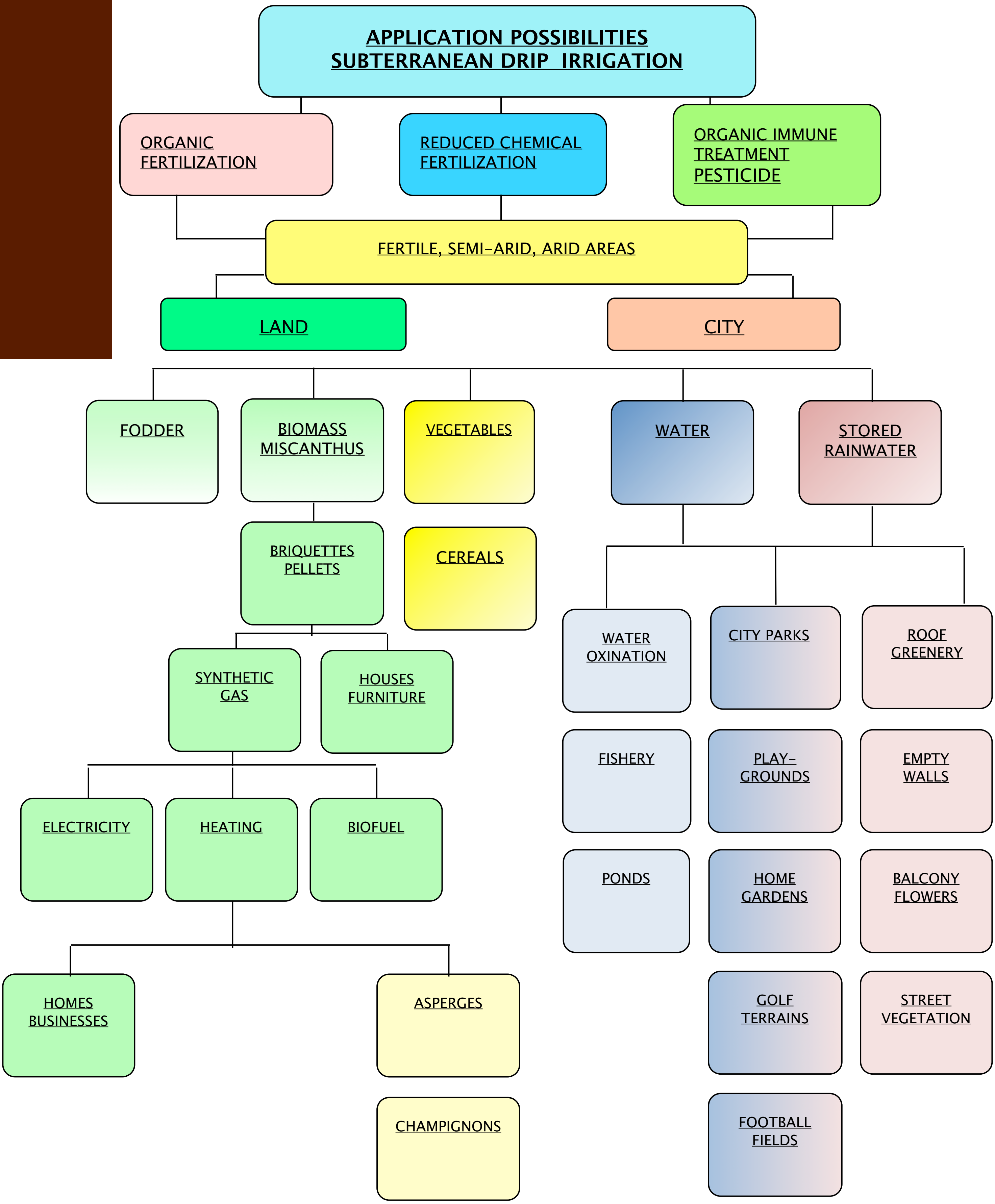
The Control Station

A robust water and nutrient control station

Example of a Home Garden Irrigation System

Schematic of a home vegetable garden irrigation system




APPLICATION POSSIBILITIES
SUBTERRANEAN DRIP IRRIGATION
ORGANIC FERTILIZATION
REDUCED CHEMICAL FERTILIZATION
ORGANIC IMMUNE TREATMENT PESTICIDE
FERTILE, SEMI-ARID, ARID AREAS
LAND
CITY
FODDER
BIOMASS MISCANTHUS
VEGETABLES
WATER
STORED RAINWATER
BRIQUETTES PELLETS
CEREALS
SYNTHETIC GAS
HOUSES FURNITURE
ELECTRICITY
HEATING
BIOFUEL
HOMES BUSINESSES
ASPERGES
CHAMPIGNONS
WATER OXINATION
CITY PARKS
ROOF GREENERY
FISHERY
PLAY-GROUNDS
EMPTY WALLS
PONDS
HOME GARDENS
BALCONY FLOWERS
GOLF TERRAINS
STREET VEGETATION
FOOTBALL FIELDS

Functionality

The SPS system can be operated both manually and automatically.

Manual operation:
The system can be operated manually by using some simple measuring devises and operate a water pump. This is recommended for small scale application and for places where transport of spare parts is not possible or uneconomical.
For the average farmer the system is designed to be as simple and robust as possible.

Handheld Moisture Temperature & Salinity Sensor

Automatic operation:
It is also possible to apply computerized digital feeding control (see section 'data logging and control').

Technology:
It is possible to add a simplified handheld soil moisture measuring device.

The SPS System is conceived in such a way that the farmer can use either a manual operated or an electrical pump

In western circumstances farmers that have more than 10 Ha may want more efficiency, and therefore may want to use computerized automatic control (see figure 9).

In a developing country the farming community could also add the possibility of computerized automatic water and nutrition control for a larger area.

In modern times, however, it is necessary to act wisely and carefully when integrating modern technology to local farming practices. Digital uniformity may destroy indigenous farming knowledges and practices.

For SPS applications it is possible but not necessary to mechanize and digitalize the whole farming process.

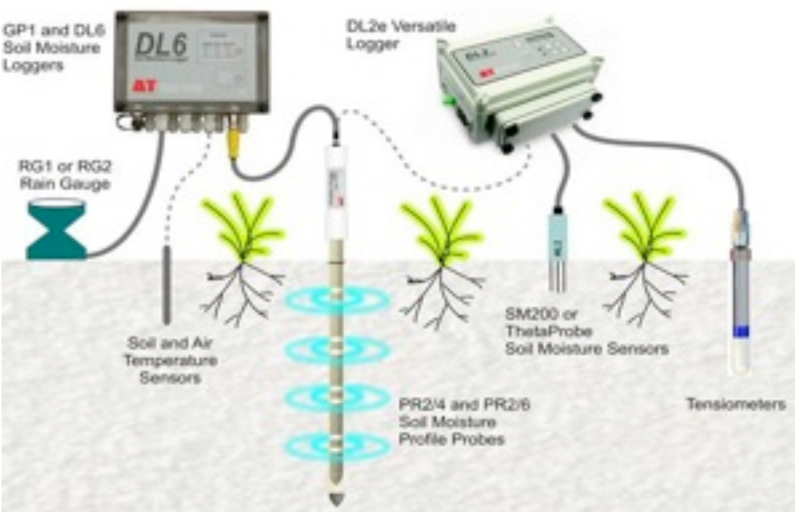


Figure 9. Measurement devices that can be easily used by farmers for the SPSS on site (7)

Simple Monitoring Methods

It may be unsustainable for long-term agricultural development to teach the farmer to rely on digital instruments only. If farmers stop using their senses and farming practices learned from ancestors, indigenous knowledge could be destroyed forever.

Using just innate natural senses can be scientific if supported by research. This is demonstrated by the elegant work done by our friends Michael Battam, Bruce Sutton and David Boughton from Australia (8).

"In semi-arid or arid areas with little water the farmer can nevertheless design a simple moisture monitoring devise by digging a hole parallel to the crop to observe both the moisture pattern and root development (see pictures to the right)."

"Soil pits (9) are a simple design aid for subsurface drip irrigation systems"

'The soil pit method'

"The new method involves installation of a trial irrigation system using thin-diameter polyethylene tube emitters. Soil water flow is then monitored by observation of the wetting front (WF) on the face of a soil pit. Good agreement was found between the WF observed using the soil pit method and neutron moisture meter measurements of soil water content taken at the field sites".

Data from the soil pit method was used to derive design parameters for drip irrigation systems at field sites.

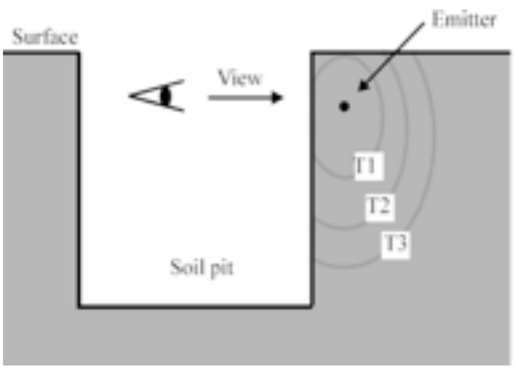


Figure 10. Monitoring system used with the soil pit method (T1, T2, T3 indicate three different times of observation)

Figure 11. Position of the wetting front after 10 h irrigation applied at 1.7 l h) from simulated emitter installed at a depth of 0.30 m

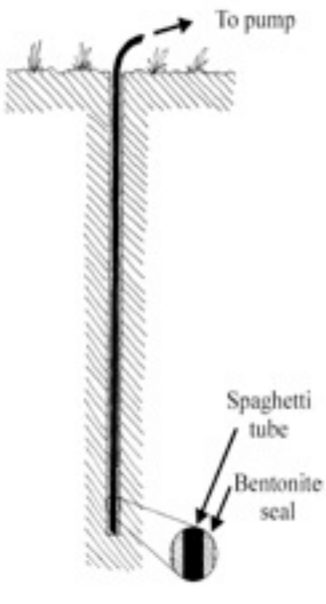


Figure 12. Schematic showing the thin-diameter (spaghetti) tube emitter installed in the soil. The bentonite seal is also shown for those cases requiring a seal

Efficiency of Water Use

1.Evaporation of water from the soil surface is practically stopped and weed growth is minimized.

2.Water excess or local concentration of moisture does not occur.

3.Oxygen is important for the soil. With SPS the large pores always remain nearly free of water. The soil consequently will have enough air supply. Even extra oxygen could be added to the water through the tubes.

4.Nutrients for growth and protective substances are precisely dosed, added to the water and distributed homogeneously by the capillary action of the soil.

Research Possibilities

Research possibilities for any local University in cooperation with Cottbus, Germany and Wageningen, The Netherlands

a) Logging data of nutrients
b) Logging data of plants
Logging data of soil via SPS

a) Logging data of nutrients and harmful substances in the soil

To assess the growing potential in specific local soil conditions, it is possible to conduct research as a first step towards the installation of the system on a larger scale. A subterranean water-conducting tube connects the test position in the field with the laboratory. On one end in the field, there is a capillary membrane, with pores smaller than one micron. On the other end, in the laboratory the tube is maintained under vacuum to ensure that the water is sucked from the direct vicinity of the membrane. Because of the small inside diameter of the tube (in proportion to its volume) the water arrives at the laboratory within a very short time, where the most important soluble components (nutrients as well as harmful substances) are measured continuously by affordable spectral methods. Obtained data serve ecological evaluation of the soil and are of great importance for establishing an optimum plant feed.

b) Data logging by sensors of the plant

In this kind of research, two novel sensors are mounted on the stem of a chosen pilot plant without any damage. One sensor measures the total water flow of the plant under the bark, the other the moisture status.

By means of a mathematical program it is then possible to correlate water consumption or photosynthesis respectively with the growth of the plant. Basis for this being:

‣The opposing gas exchange between the CO2 of the air and the water-stream leaving the interstomatal cavity of the plant.

‣The relative humidity, photosynthesis, growth rate and maintenance respiration (the principles of which are known).

As already mentioned, through a second method the water status of the plant can be measured precisely. Therefore, for the first time it is possible to get data about metabolic processes in the plant, which to a large extent correlate with the moisture conditions in the cells.

Both methods can be applied under field conditions, for seasonal as well as perennial cultures. The sensors must be attached in such a manner that the growth of the plant is not disturbed at all. This has been done, amongst others, with orange trees in Greece, on which tests have been performed throughout many years (see pictures 14 and 15).
By these methods one obtains a deeper insight into the mode of living of the plant.

c) Control via SPS

One dream of professor Staender was that all SPS projects become linked as far as collection of plant and soil data are concerned. The soil water status of all projects can be transmitted wireless and submitted online to a central research laboratory. It is then continuously integrated into a program to improve the underlying plant dozing algorithm. Furthermore it is possible to incorporate scientific knowledge derived from botanical and agricultural literature into this algorithm. This will allow the addition of plant protection substances, herbicides and growth stimulants, which are available in nature, into a dozing mechanism. From this integrated knowledge higher yields will result until the biological highest possible yield and an optimum quality of the harvest are reached. This is the dream of Prof. Staender. One step to global biological agriculture.

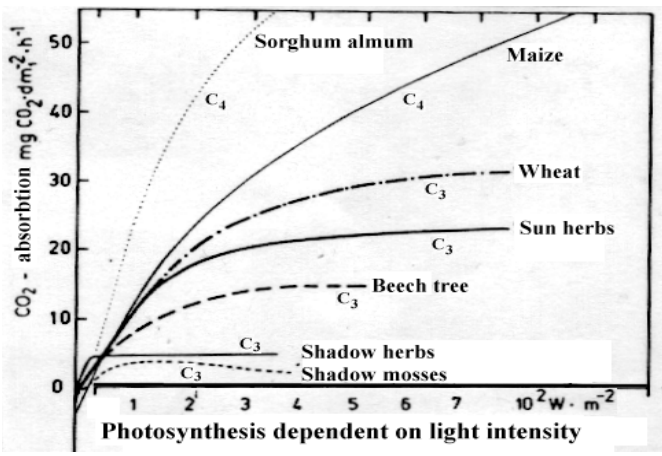


Figure 13. Picture taken from the first biomass yield study of Prof Staender, 1989 for the European Commission. It shows that non-food C-4 plants like Sorghum Almum and Miscanthus are the most efficient biomass producers (10).

Summary: SPS System

In the future it will be possible to monitor biologically the growth of agricultural products by technical means. These are data acquisition in soil and pilot plant to regulate for an optimum growth by timely adding natural plant protection substances. It is assumed that depending of the local situation two to four times the amount of harvest against today's average can be achieved.

Water will receive just enough substrates (fertilizers, trace elements, respectively waste, water-, growth- and others).

Over-supply of the plants and soil-erosions cannot happen. The groundwater will not be chemically affected in a harmful way and the soil remains in its natural condition.

Not only in horticulture, but also in agriculture the opportunities will be available for growing biologic-dynamic products with a yield and quality level never reached before.

Figure 14. Apple tree plantation with standard surface irrigation

Figure 15. The same apple tree plantation after three months with subsoil irrigation

Natural growth- and protective substances which are very sensitive against UV-rays, light, high temperatures and atmospheric oxygen, were not used previously in agriculture due to their easy decomposition. However, with SPS it becomes possible because the time between the addition of such substrates and the absorption through the roots is usually only a few hours. Thus, substances of plant-origin will quickly decompose through soil microorganism. However, if desirable to delay decomposition for some reasons, this can be achieved by adding natural anti-bacterial substances.

Use of Natural Substrates

Protective substances against pests, produced naturally by the plant itself like well-known strawberry flavor against the mildew surely have not been invented by nature to satisfy the taste of humans. Most natural flavors similarly serve multiple purposes. Their useful qualities can be utilized by means of SPS. Plant extracts could be produced by agriculture and, if necessary, synthetically. Only a few grams per hectare is often sufficient (particularly if used at the right time) to protect a plant culture from pests.

The fight against soil parasites through SPS is particularly interesting. As already mentioned, it is possible to create a homogenous parasite level against nematodes (for instance with tagetes-extract) during a long period of time. In that way larvases will be wrecked, and mice and moles will be dispelled by means of natural smelling fragrances (like garlic juice).

Lime milk (and certain organic acids) can be used. One can even match the pH-value of the soil precisely to the requirements of the plant.

Waste heat (as a by-product of biogas power plants) can be utilized for warming up the soil by pumping warm water through the irrigation hoses just below the pressure they begin to open. By that harvests can be obtained earlier with much higher yields.

The growth of plants can further be improved by the following methods:

- With carbon dioxide, which is supplied in solved form with water to the plants.
- Blowing compressed air through the tube-system or by solving air into the water. The latter is very effective with heavy soils.
- By using treated waste water, respectively, decanted liquid manure (as a replacement for fertilizers) a harmful substance will be re-functioned into a useful nutrient.

SIS COMPANY INFO

INTERNATIONAL OFFICE

SiS International
Postbox 43008
3540 AA Utrecht
The Netherlands

e-mail info@sustainableinnovations.org

GERMANY

SiS Germany
Goethestrasse 95
01365, Guben, Germany

Ir.G.H. Franke
Director
e-mail Geha.franke@online.de

Ir H. Wetzel
Co-director
e-mail howetzel@t-online.de

NETHERLANDS:

Drs. Johannes Krens
General Manager
e-mail jkrens@sustainableinnovations.org

BSc M.S. Krens
Consultant
e-mail mkrens@sustainableinnovations.org

BSc P.F. Stadhouders
Energy Consultant
e-mail pstadhouders@sustainableinnovations.org

Contributions

1. This text was originally drafted by Prof Dr Staender †.
2. Information organized by Ir Gerd Franke
3. The text was finalized by Pieter Stadhouders & Drs. Johannes Krens

References

(1) Lamm, Dr. Freddie R., "Advantages and Disadvantages of Subsurface Drip Irrigation" Research Overview, Northwest Research-Extension Center, Kansas State University (e-mail to the author: flamm@oznet.ksu.edu)

(2) http://www.hendrikus.com

(3) http://www.hendrikus.com

(4) www.netafim.com

(5) Lamm, Dr. Freddie R., "Advantages and Disadvantages of Subsurface Drip Irrigation" Research Overview, Northwest Research-Extension Center, Kansas State University (e-mail to the author: flamm@oznet.ksu.edu)

(6) Soil Web. From http://www.hendrikus.com

(7) Delta-T Devices Ltd; http://www.delta-t.co.uk

(8) Battam, Michael A., B.G. Sutton, D. G. Boughton "Soil Pits as a Simple Design Aid for Subsurface Drip Irrigation Systems". Irrigational Science (2003). Vol. 22. pp. 135-151

(9) Ibid

(10) Prof. Staender, 1989. "Determination Of The Highest Biomass Producing C4 – Grasses Of The World For Temperate Climates" to be republished by SIS International.