THE NOVEL APPROACH TO A SUSTAINABLE AGRICULTURE IN DRY COUNTRIES
GUILSPARE is a new soil treatment process, invented in the Nestlé® Research Centre in Switzerland, and now proprietary to Guilford Holding S.A. who own all patent rights. It is designed to limit water use for agriculture in dry countries. The Arabian Peninsula is now suffering the world’s most acute water shortage. The potential water saving with GUILSPARE in this region alone is estimated to be over 10 000 000 000 cubic metres per year.

And many other arid parts of the world, on the five continents, will also benefit from this new water management technology, to make comparable water and cost savings.
70 to 90% of all fresh water today is used for agriculture.

Reducing this by only a tenth would approximately double water for domestic use.

Many countries of the world are short of water. Yet, their soils are often so fertile that, with irrigation, they can bear crops.

Worldwide, some 70-90% of all fresh water today is used for agriculture. Reducing this by only a tenth would approximately double water for domestic use. As such, agriculture offers the potential for the massive water savings needed in order to help guarantee sustainable fresh water supplies and food production.

The question is how to lower the amount of irrigation water used.

**GUILSPARE®** is a new, revolutionary soil treatment technology that offers an answer, by preventing soil water from evaporating, a major problem for farmers on arid soils. It consists of treating the soil to create a non-wettable surface layer that forms a very effective barrier against evaporation.

**GUILSPARE®** has been field-tested in Spain (ref. 1), and also on the Arabian Peninsula (ref. 2) where most countries are using their supplies of fresh water faster than the natural replacement rate. In Saudi Arabia, for example, some 90% of all water used is non-renewable.

But water saving is not the only advantage offered by **GUILSPARE®**
- Soil water content in the rooting zone is increased.
- Plants grow stronger and fruit earlier.
- Crop yields show an increased efficiency of water use, so farmers with water quotas can plant greater surfaces with the same amount of water.
- The growing season can be extended, planting earlier or later.
- Soil salinity is lowered.
- And... growth of weeds is very significantly reduced!

In comparison with other products offered to date, **GUILSPARE®** is easy to apply. It is sprayed on the ground, at about one teaspoonsful of active product per square metre, using standard agricultural machinery for dispensing liquids.

In regions exposed to winds, **GUILSPARE®** can be co-applied to the soil along with **SACRUST®** (ref. 3). The latter is a soil stabilising agent, also environment friendly, that fixes the soil surface against winds up to 65 km/hour. This helps to ensure the efficiency of the **GUILSPARE®** treatment.

Results both from Spain and the Arabian Peninsula show that **GUILSPARE®** can save 25-50% of the total irrigation water currently needed. In fact, on the Arabian Peninsula, where a farmer, on average uses about 16'000 m³/ha/year of irrigation water, this would mean saving at least 4 000 m³/ha/year.
Results to date with GUILSPARE

The GUILSPARE treatment is particularly efficient when combined with drip line irrigation, commonly used in most arid countries.

As the lower photograph shows, okra plants growing at Sultant Qaboos University Experimental Farm in the Sultanate of Oman show a much more abundant foliage and give higher yields when grown on soil treated with GUILSPARE (ref.3)
Weed growth on the Experimental Farm of the Institute for Natural Resources and Agrobiology in Sevilla, Spain, is visibly reduced on soil treated with GUILSPARE, lower photo, compared to non treated soil, upper photo (ref. 2)

GUILSPARE is a water-based liquid product, easy to apply
Applied around trees, GUILSPARE also lowers irrigation water requirements and limits weed proliferation.

GUILSPARE treatment on soils in Spain consistently gave higher soil water contents, on average 34% greater at 15 cm depth and 53% greater at 25 cm depth, resulting in a more efficient irrigation in the rooting zone of field crops (ref. 2)
Yields of autumn planted okra in the Sultanate of Oman, are greatly increased when using GUILSPARE, even with only 49% the normal irrigation water applied (ref. 3)

A much increased water use efficiency is seen for okra production on GUILSPARE-treated soils (ref. 3)
"All Life is Water"
Thales, ca. 400BC

Figure 1: Only 0.015% of the earth’s water is readily exploitable (ref. 5)

WATER: A VALUABLE COMMODITY THAT NEEDS EFFICIENT MANAGEMENT

Water is essential for food and life, and needs efficient management. It is the most abundant substance on earth. But as Figure 1 shows, most of it is either unsuitable or impractical for direct use. Only about 0.016% is “clean”, and readily exploitable (ref. 4).

Exploitable water is thus finite and, according to the UN, it is already not sufficient for today’s global population, growing by about 300,000 per day. From 6 billion in the year 2000, the UNO predicts 8 to 12 billion by 2050, and, in the worst case scenario, as many as 23 billion by 2200.

Yet demand for water constantly increases with the growing need year by year to produce more food (ref. 6). Water, even in the short term, is a major macroeconomic factor. The coming decade will see a Water Revolution.

One of the conclusions at the FAO World Food Summit held in Rome in November 1996 (ref. 6), and repeated in the 2nd World Water Forum in the Hague in March 2000 (ref. 8), was that new technologies for water management are urgently needed. GUILSPARE® is thus appearing on the scene at a favorable moment.
Figure 2: Composition and structure of soil (for simplicity, solid particles are shown as identical spheres). Solid particles consist of: coarse sand (2.0-0.2 mm Ø), fine sand (0.2-0.02 mm Ø), silt (0.02-0.002 mm Ø), clay (< 0.002 mm Ø), and organic matter (fibres and lignins). Soil also contains microorganisms and other living organisms, and soil-water contains dissolved acidic, basic or neutral mineral salts.

**Soil Structures, and Availability of Water for Growth**

The physical properties of all soils, as well as their different abilities to support plant growth, depend on the soil structure and composition. This is shown schematically in Figure 2. The size distribution of solid particles in a given soil determines not only the amount of water it can hold, but also the availability of this water to plant roots. This is outlined in Table 1 for two extreme soils, sandy loam and heavy clay.

Most agricultural soils in arid countries are light and sandy with low organic content and, on these, **GUILSPA®** works well.


<table>
<thead>
<tr>
<th><strong>Table 1:</strong> Physical characteristics of two extreme soil</th>
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<tr>
<td><strong>Sandy Loam</strong></td>
<td><strong>Heavy Clay</strong></td>
</tr>
<tr>
<td>Mostly Sand Particles</td>
<td>Mostly Clay/Silt Particles</td>
</tr>
<tr>
<td>2.0-0.02 mm Ø</td>
<td>Mainly &lt; 0.002 mm Ø</td>
</tr>
<tr>
<td>Low Water-Holding Capacity</td>
<td>High Water-Holding Capacity</td>
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<tr>
<td>High Permeability</td>
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<tr>
<td>High Water Mobility</td>
<td>Low Water Mobility</td>
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<tr>
<td>High Water Availability</td>
<td>Low Water Availability</td>
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Two major factors for crop growth and yield are (i) the quantity of water in the soil and the ease of mobility of water through the soil: together, these determine the availability of water to plant roots.

Figure 3A shows the main water movements in soil. Free water at the surface... from rainfall, or dew, or irrigation... descends by gravity into the soil. Ground water held in the soil moves upwards as a result of capillary forces.

Water losses in agricultural practice are related to these water movements. As shown in Figure 3B, losses arise from (a) evaporation of soil water, (b) evaporation of free water at the surface, (c) deep percolation of water, (d) transpiration of water through plant leaves (note that transpiration rates differ widely between crops).

"Farmers will soon have to pay for water at its real price”

Kemal Dervis
Vice President, World Bank

GUILSPARE® directly prevents water losses due to soil-water evaporation, and will indirectly reduce other losses by allowing a more controlled application of irrigation water, thus minimising the perceived need by many farmers in arid zones to overwater. In fact, most of the world’s farmers still irrigate the way their ancestors did 5 000 years ago (ref. 9).

GUILSPARE® has no known effect on limiting losses due to plant transpiration since this depends on the nature of the crop and not the soil. Permitting transpiration means that conditions for crop growth and yield are maximised.
How GUILSPARE® works is shown in Figures 4A and 4B. In an untreated soil (Figure 4A), capillarity constantly pushes water in the soil upwards to the surface, where it evaporates.

The GUILSPARE® process consists of treating the surface of the soil (Figure 4B), to a depth of 5-30 mm, to cover the surfaces of individual soil particles with a molecular layer of a silica-based polymer. This renders them hydrophobic (i.e., water repellant), as shown in Figure 5, thus creating a physical barrier that largely prevents soil-water evaporation.

In effect, GUILSPARE® neutralizes capillary forces in the treated layer, so the upward migration of soil-water to the surface is no longer possible (Figure B). However, it is important to note that the hydrophobic layer does not prevent the uptake of irrigation water. It is equally important to note that the active component of the GUILSPARE® treatment is an environment-friendly product with no known biotoxicity to living organisms.

GUILSPARE:
AN EFFECTIVE BARRIER AGAINST EVAPORATION OF SOIL-WATER
Figure 6:
Water retention in sand treated with GUILSPARE to different depths from 5-30 mm

GUILSPARE IN PRACTICE

Figure 6 shows the results of trials to test the water retention properties of GUILSPARE®. The efficiency against evaporation losses depends on two factors, namely the depth of treatment and the concentration of the active water repellant species on the soil.

A typical farming operation, from sowing to harvesting, is shown schematically in Figure 7. After sowing, the soil remains bare until the first leaves appear. During this time, water losses due to soil-water evaporation are highest. As the plant grows, transpiration becomes the main source of water losses, but soil water evaporation is still a factor.

GUILSPARE®, applied at the start of the growing season, saves water over the whole growth cycle, but especially during the “bare soil” period.

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Figure 7:
Scheme of the growth cycle from seed to crop, where
Db = number of days with bare soil and Dt = total days from seeding to harvest
The equation of Figure 8 expresses the **Annual Water Loss (AWL)** in agricultural practice due to water evaporation from soil over the whole plant growth cycle from seed to crop.

In this formula, $D_b$ and $D_t$ are crop-dependant, and vary from 35 and 90 days respectively for beans, to 80 and 310 days respectively for artichokes.

Introducing into this equation average values for $D_b$ and $D_t$ for a number of crops, along with empirical values, for the sandy soils typical of the Arabian Peninsula, namely, $PET = 7.8$ mm/day, $K_c = 0.9$ for bare soil, and $K_c' = 0.15$ for covered soil, we may estimate the average Annual Water Loss from the sandy soils of the Arabian Peninsula to be $5'080 \text{ m}^3/\text{ha/year}$.

Even if **GUILSPARE**® is only 80% efficient, the water it saves in preventing evaporation loss would be $4'068 \text{ m}^3/\text{ha/year}$.

But in addition to direct water savings, there are also indirect savings. These come from changing the current practices of local farmers who systematically over-irrigate to be sure they keep enough water in the rooting zone of their crops, which increases losses due to percolation.

In 1997, based on **GUILSPARE**® trials in the laboratory, we predicted that the total water saving would be about 30%. Subsequent agricultural trials, as outlined earlier in this document, show that a real saving of 40% is a realistic goal. On the Arabian Peninsula, this would amount to $6'400 \text{ m}^3/\text{ha/year}$.

**“In Spain, crops are dying for lack of water”**

Dr E. Fernandez, Institute for Natural Resources and Agrobiology, Seville, Spain

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**AWL = [PET (kc ∙ Db + kc’ ∙ (Dt − Db))] ∙ 10 (m³/ha)**

Where:

- $PET =$ potential evapo-transpiration in mm water/day
- $kc =$ fraction of water lost due to soil-water evaporation from bare soil
- $kc' =$ fraction of water lost due to soil-water evaporation from covered soil

and $Db$ and $Dt$ are as defined in Figure 7

**Figure 8:**
Annual Water Loss (AWL) due to soil-water evaporation during a whole plant-growth cycle.
**Potential Market for GUILSPARE**

We take again here the example of the Arabian Peninsula, with over 2 million hectares of irrigated cultivation. If all of this agricultural land surface were treated regularly with **GUILSPARE®**, this region could benefit by saving of the order of 10 US billion cubic metres of irrigation water per year. However, **GUILSPARE®** also has a number of potential markets in other parts of the world: for example, South Africa, Australia, China, Central America and the USA.

Further, there is a growing awareness at the level of governments on the need to act. Water can no longer be seen as free. It has a cost, and for the most part is highly subsidized. Figures from the Sultanate of Oman show a real cost of over 50 US cents per cubic metre. And the State of California has set up the California Irrigation Management Information Service to help farmers plan their irrigation schedules to improve water use efficiency. In making it possible to reduce water use **GUILSPARE®** has a key role in Good Farming Practice endeavors to achieve agricultural sustainability and to preserve one of the most valuable natural commodities in the world... fresh water.

**Additional Benefits of GUILSPARE**

1. **Reduction of weed growth, and the need for herbicides, since GUILSPARE®** gives a dry layer at the surface of the soil that prevents germination.

2. Possibility to collect water deposited as dew, particularly in arid coastal regions.

3. **Prevention of soil salinization, or remediation of salt affected soils, common in many coastal regions of the world.**

4. Based on the **GUILSPARE®** principle, Guilford Development SA also proposes a pre-treated soil, **GUILSOL**, for use on ornamental parks and gardens and for domestic use on house plants, window boxes and gardens, to limit the frequency of watering. This product has been tested in Spain, with success, along the motorways in Andalusia and the Parks and Gardens Department of the city of Seville.

**The Water Revolution**

**GUILSPARE®** in improving the efficiency of use of irrigation water in dry countries, is a major step forward in the Water Revolution, which will fundamentally change methods of water management over the next few decades. The recent past has seen the evolution of drip irrigation now used on over 1 million hectares of land in the USA alone.

The near future will bring further technological advances, like breeding plant varieties with reduced transpiration rates. The complementarity of these and other solutions will help guarantee sustainable agriculture in dry countries with an optimum use of water.

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“My fear is that we are headed for a period of water wars between nations”

Klaus Toepfer, Head of UN Environment Programme
WATER: A COMMODITY IN DANGER!

Problems related to water already affect 3 billion people and will affect the population of the whole world in the next 50 years. Since 1950, needs have doubled in the USA, tripled in Africa, and increased fivefold in Europe! Since agriculture accounts for some 70-90% of all water used, GUILSPARE offers a timely solution to a part of the problem.

REFERENCES
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