



The potential of silicates in leather production Part 3 of 4

Utilisation of soaking liquors for irrigation

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Major benefits from the use of sodium silicate in leather manufacture have been researched and developed. The project—with the acronym “SILIC-SALT”—was funded under the EC programme INCO-DEV⁹. Four important sets of findings were gained from this project:

1. *Silicates can be successfully used for the long-term preservation of hides and skins, and the subsequent manufacture of commercially acceptable leathers.*
2. *Within leather processing:*
 - *Lime can be replaced by silicates within the liming and unhairing process.*
 - *An additional silicate penetration/neutralisation of pelts led to improved uptake of tanning and retannage agents, dyestuffs and fatliquoring—hence rationalised and cleaner processing.*
 - *The development of new trading commodities.*
3. *Silicates in tannery wastewaters are not detrimental to plant health. In contrast, common salt at levels normally found in tannery effluents is highly detrimental.*
4. *Information regarding silicate related chemistry, and interactions within leather manufacture at fundamental level.*

Parts 1 and 2 were published in World Leather February/March and April 2006. Findings listed as 4 are presented as Part 4, and will be published in World Leather in June/July 2006. Each part presents the findings from that component of the investigation.

Salinity stemming from leather manufacture

About one third of the world's population lives in countries with moderate to high water stress—that is to say, in areas where the withdrawal of fresh water exceeds 10% of the renewable storage. Increasing populations aggravate these problems, and the worst situations are found in Africa and western Asia.

The potential gains from a secondary use of grey-waters for agricultural irrigation in these areas is high, but this can only be achieved if the waters are fully-suited to the local environment. Salinity, in particular, is a major issue.

Within leather manufacture, excluding water required for processing, more salt is used than any other material. Based on a global use of nearly eight million tons of bovine hides, sheep,

goat and pigskins, as wet salted hides and skins, the weight of salt consumed in their preservation and conversion—and discharged from tanneries—is considerable. Salt remains an untreatable component of tannery effluent, so if these grey-waters are used for irrigation, then the salinity increases in the surface soil mainly due to evaporation. Tannery effluents are used for irrigation purposes, but only where preservation is free of salt, and where good working practices are followed.

The replacement of salt by silicates as a means of preservation

Silicates offer a means to replace common salt in the preservations of hides and skins. The salinity arising from the


Panel 1: Crop irrigation: the effects of water silicate and saline solution on the growth and development of beans

Irrigation method: Water

Irrigation method: Silicate solution

Irrigation method: Salt solution
Panel 2: Crop irrigation: the effects of water, silicate and saline solutions on the growth and development of potatoes

Irrigation method: Water

Irrigation method: Silicate solution

Irrigation method: Salt solution
Panel 3: Crop irrigation: the effects of water silicate and saline solution on the growth and development of leeks

Irrigation method: Water

Irrigation method: Silicate solution

Irrigation method: Salt solution

soaking silicate-cured hides and skins at 20% silicate application is less than 2% of the salt arising from conventional salt-cure. This means that the salinity of tannery grey-waters—at approximately 10,000 mg/l sodium chloride content (1% salt solution)—can be immediately reduced by around 50%. Coupled with good environmental practices this provides the potential for crop irrigation where water resources are limited.

The effects of silicates and saline grey-waters on crop irrigation

A series of carefully controlled investigations was performed to study the effects of both sodium chloride and silicates on crop irrigation. Salinity levels were “normal” for tannery effluent at 10,000 mg/l as sodium chloride (*examples are found that are*

considerably higher than this value). The silicate offer was based on 1700 mg/l sodium silicate adjusted to pH 7.0 using formic acid.

pH 7.0 was used, as silicates are very difficult to keep in solution below this pH. In the investigation the pH adjustment caused a gel (*silicon dioxide*) to be formed and an increase in viscosity. In practice it is most unlikely that silicates would survive tannery effluent treatment as they also react with many components to form precipitates. However, it was believed essential to use a worst case situation, as no quantitative information was available for the effects of silicates on crop growth and yields.

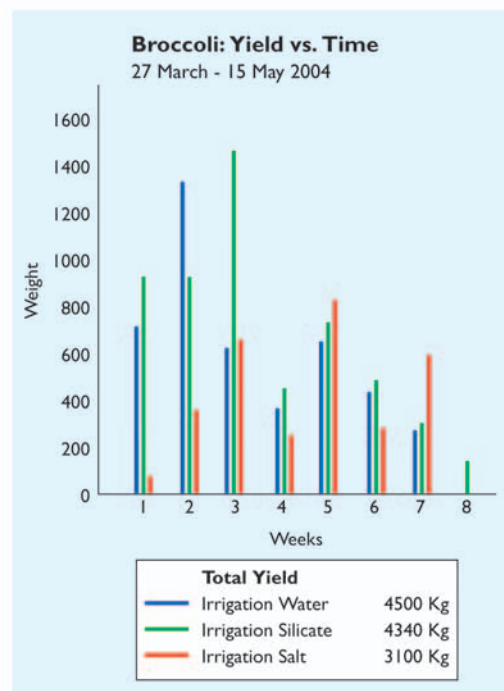
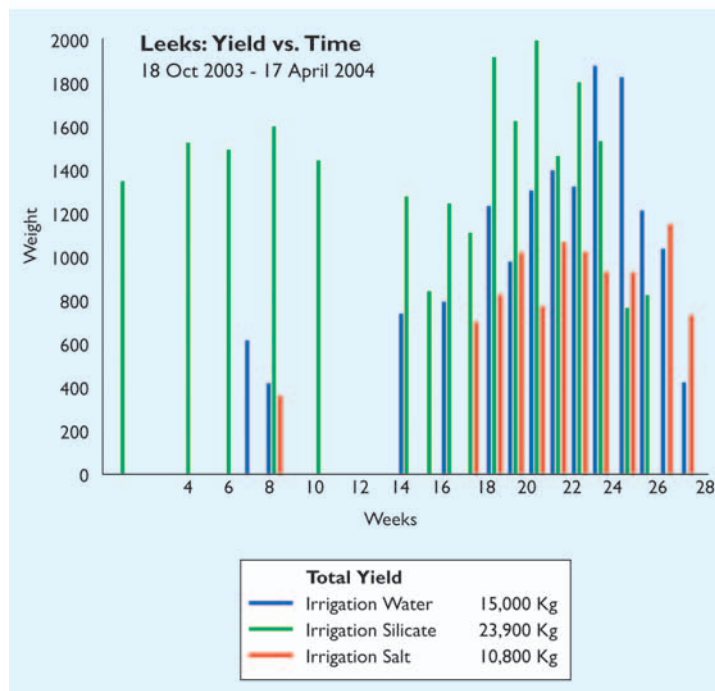
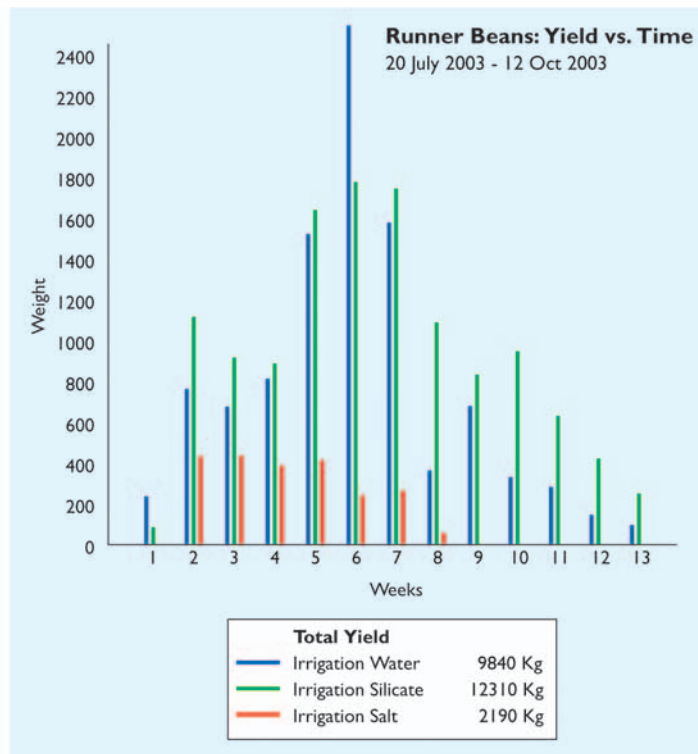
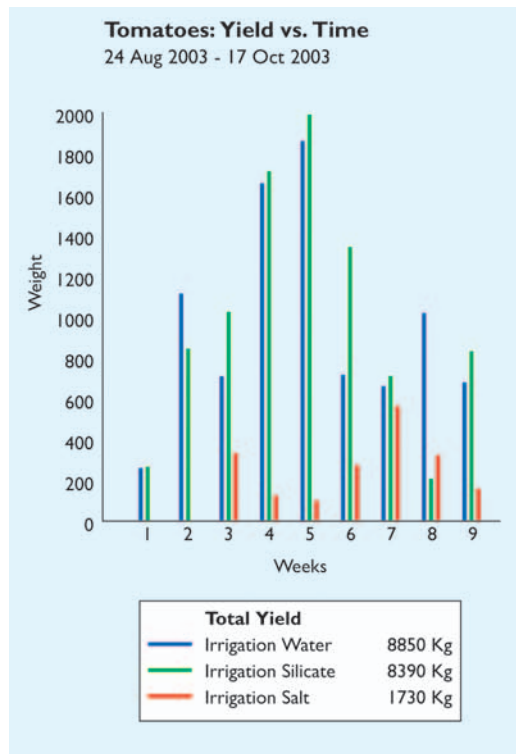
The investigation

Five major crops were grown in carefully controlled field trials over two years. One crop (*tomatoes*) was grown under ➤



THE POTENTIAL OF SILICATES IN LEATHER PRODUCTION

Panel 4: Crop yields vs. Time



Note: the Total yields for potatoes was: **Water 26.7 Kg**, **Silicate 36.3 Kg**, **Saline 15.4 Kg**

Irrigation with salt solution

- Tomatoes: Considerably stunted growth with coarse fruit of unhealthy appearance. Beans: Pods were coarse, discoloured stunted and fibrous Broccoli: The tolerance to salt was greater than for tomatoes and beans, but the leaves were coarse and smaller in area, with a large increase in the proportion of leaf-vein and stem. Potatoes and leeks: Smaller and whiter than comparative specimen. The flavour and texture was normal.
- The cropping period for tomatoes, potatoes and beans occurred during a hot dry summer and autumn. The cropping period for broccoli and (saline) leeks was late winter/early spring. It was considered that all of the salt has been washed from the root structures during a long wet winter.
- Note: There was no significant difference between crops irrigated with water or silicate solutions.



greenhouse conditions. Four crops (*beans, leeks, broccoli and potatoes*) were grown outdoors. Each crop was sub-divided into three sections, each section being irrigated with water (*control*), silicate and saline solutions. The volumes applied were at the same volume as the demands of the water-irrigated crops. All of the outdoor crops showed common trends, and the illustrations given as *Panels 1, 2 and 3* are typical.

These photographs show that salinity is a disaster and this was common to all crops. However, both growth, quality and yield were improved when crops were irrigated with silicate solutions—even when compared with the water control.

The performance can be better evaluated, as it was possible, with the exception of the root crop of potatoes, to harvest the crops as individual specimens as they reached a specified size. This provided a weekly yield across the whole cropping period, and the findings are shown in *Panel 4*.

Crop yields are available that express total yield as a result of salinity, and these values as part of "Total Yield" given in *Panel 4* were broadly in-line with these guidance values for farmers. However, no details were found that expressed yield across a full cropping period as presented in this *Panel*.

Very little information is available regarding the effects of silicates on plant growth. The subject of plant siliconology is relatively new and a comprehensive role of silicon in plant health has not been formed. However, silicates are seen as non-toxic, of benefit for some crops such as rice and sugar cane, and have been described as "a non-essential but beneficial nutrient". No information was found that provided either total crop yields as a result of silicate-irrigation, yields expressed across a cropping period, or provided comments on the quality of the product.

Attention is drawn to the following points:

- Plants show different tolerances to salinity. The effects were very detrimental to all crops investigated. Moreover, the quality of all saline-irrigated crops was much lower than the outcome from the other two techniques: the colour was darkened, and the crops coarser in texture with a dry wind-burned appearance.
- The yields of beans, leeks, and potatoes are much higher when irrigated with silicate solutions compared with water. This appeared to be typical under hot dry conditions and is believed to be due to improved water retention. In the case of leeks this created conditions for earlier cropping. Similar patterns were found in smaller test investigations using other plant species, and confirmed in second-year investigations.
- The yields from tomatoes when water and silicate solutions were used for irrigation were similar. This was the only crop grown where water percolation away from the root structure was prevented, the roots being individually contained. The broccoli yields were very slightly higher when water was applied compared with silicate solution, but this was the only example found in two growing seasons.

Other observations and findings

Other matters were noted during the investigation.

- At the end of the first year investigations, the number of

micro-organisms in the soil appeared similar irrespective of water or silicate irrigation. Almost no micro-organisms could be observed in the areas irrigated with salt solution.

- Solutions of silicate, salt and water were left exposed to the air. Similar species of micro-organisms of similar population density became established in both water and silicate solutions. The salt solutions remained sterile.
- Crops irrigated with water were grown in the second year on the test site. Crops grown in areas irrigated previously with water and silicate produced similar yields, but areas previously irrigated with saline solutions produced lower yields.

Findings from the crop irrigation component of the investigations

- Saline solutions, at the strength typically found within treated tannery effluents, cause a massive reduction in crop yields by weight and in terms of quality. Salinity is also detrimental to micro-organisms within the soil. In addition, the yields from crops irrigated with water, but grown in areas previously subjected to saline irrigation are reduced.
- If silicates replace salt as a means of preservation then, with good environmental attention, there is potential for the use of tannery grey-waters for crop irrigation.
- It is likely that silicates are removed from solution during conventional effluent treatment. However, no detrimental effects have been found in crop yield, quality or taste when silicate solutions are used for irrigation on a wide variety of crops.
- There are indications that silicates can improve crop yields. This may be due to greater water retention near to the root structure, although other mechanisms may be involved, as plant siliconology is a relatively new field of study.

Legend:

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3. Central Leather Research Institute
4. Greentech + Associates
5. Lederfabrik Vogl GmbH & Co Kg
6. Bangladesh College of Leather Technology
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