Growing alfalfa in the saline-sodic soil of Torreon, Mexico.

The Lala project success story

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In December 2018 we established 2 IAAS projects of 90 ha each in the alfalfa farms of LALA, a big dairy company in Torreon, located in the arid northeast of Mexico. When we received the water and soil analysis, we understood that it is going to be a challenge, since the soil contained high levels of salts, sodium and carbonates, and water quality wasn't good either.

Alfalfa is usually grown in arid areas, despite the soil and water challenges, but why?

Alfalfa has been called the "queen of forages" with the highest crude protein content of 22-26%, compared for example, with corn 7-10%, bermudagrass 7-16% and Vicia (vetch) with 18%.

Crude protein is the potential of the forage to provide protein to the livestock and reflects the quality of the forage (not the energy value). It is calculated by multiplying the N content by 6.25. But, if alfalfa is not harvested on time, before flowering starts, it loses protein (CP) and gains fibers (ADF), which reduce its quality (see table below).

Rain just before harvesting is problematic, since machinery can't enter the field, harvesting is delayed and quality starts decreasing. The low amount of rain in the desert allows to cut just on time and get high quality alfalfa. But arid areas put alfalfa up for a challenge since water is usually scarce and salty, and soil is saline, sodic, calcareous or a combination of them.

Saline soil is characterized by a high concentration of soluble salts, high EC, pH lower than 8.5, low SAR (Sodium Adsorption Ratio,) good soil structure and good water infiltration.

Sodic soil is characterized by a low concentration of soluble salts, low EC, pH higher than 8.5, SAR > 13, ESP (Exchangeable Sodium Percentage) >15%, RSC (Residual Sodium Carbonate)>2mM, poor soil structure, low infiltration and aeration and crust formation.

Calcareous soil is characterized by high Active calcium carbonate (> 10% p/p), Total calcium carbonate >35%, high pH (7.5-8.5), poor soil structure and crust formation.

In one of the projects, we had a saline-sodic soil and in the other a calcareous one.

Table 6. Change in alfalfa quality with advancing plant maturity.

Maturity	TDN (%)	CP (%)	ADF (%)
Pre-bud	65	21.7	28
Bud	62	19.9	31
1/10 bloom	58	17.2	34
1/2 bloom	56	16.0	38
Full bloom	54	15.0	40
Mature	52	13.6	42

Abbreviations: **TDN** = total digestible nutrients, **CP** = crude protein, **ADF** = acid detergent fiber. All values are expressed on a dry matter basis.

Source: Nutrient Requirements of Dairy Cattle, National Academy of Science, Publ. 1349.

"When the percentage of crude protein is low, the bacteria responsible for digestion cannot sustain adequate levels to process forage. Ultimately, the animal's intake and digestibility are reduced". (Anderson, Forage Nutrition 101).

The challenge

Alfalfa has a moderate tolerance to salinity (2.0 dS/m 100% of yield potential; 3.4 dS/m 90%; 5.4 dS/m 75%; 7.6 dS/m 50%, according to Ayers and Westcot 1976), but at the early stage of germination, the young root has difficulty to take up water from the saline soil and dries out.

SDI is the only drip solution possible for alfalfa, because of the frequent cuts and the possible damage to on-surface driplines. But in saline soil, SDI moves salts to the soil surface where germination occurs, therefore this is an issue that needs special attention.

Since alfalfa seeds are small, sowing is done on surface, and germination takes place in a hostile environment exposed to the sun, birds, and salts.

Calcareous and sodic soils form a hard crust on the surface and make it difficult for the roots to penetrate the crust and reach the soft and moist soil beneath. Corn that is grown on these farms in rotation with alfalfa, has the opposite problem: It is sown at a depth of 5.0-6.5 cm and must cross the crust upwards to emerge.

To identify a calcareous soil in the field, we used the vinegar test. Vinegar, or acetic acid has a pH of 3, so when applied to the soil surface it reacts with the carbonates, releases CO2 bubbles, and leaves holes in the soil.

Alfalfa originated in the arid area of Southwestern Asia with Iran as the geographic center, so it has evolved to seek water in the depth. For this purpose, it needs a deep and not too compact soil. Sodium and carbonates compact the soil and make it difficult for the roots to go deeper.

When using SDI in a sodic or saline soil, sodium and other salts accumulate between two driplines, causing plants to suffer from low water availability. Since soil becomes compact in that area, water doesn't infiltrate easily, and the soil becomes dry. The result is an uneven growth with higher plants along the driplines and shorter in between.

So, how did we deal with the complex soil conditions?

- Deep soil tillage, the first step in soil preparation allowing good root penetration and salt leaching.
- Closer distance between driplines (75 cm between driplines and 30 cm between drippers). To create a continuous, wide wetted strip that reduces salt accumulation in between the driplines and allows uniform water distribution throughout the plot.
- Shallow dripline installation, at 25 cm, to reduce salt accumulation in the root zone.
- We used an overhead irrigation method (flood or sprinklers) for germination.
- We applied carboxylic acid through the drip system (Promesol 5X, 12 l/ha) that reduces the negative effect of salts on soil structure and plants.
- We regularly use fertilizers with high percentage of ammonium to help lower soil pH, and a higher dose of phosphorous (10 kg P2O5/harvest) and micronutrients that have low availability in alkaline soils. Phosphorous application is done by phosphoric acid which also helps in decreasing soil pH and cleaning the drippers from carbonate residues.
- In the calcareous soil we applied sulfuric acid through the drip to soften the crust during germination. We continue applying sulfuric acid once every cycle (22-30 days normally), with a pH 4.0-4.5 for 2 hours.

Applying compost to increase the soil organic matter can also be helpful in such cases, but we chose not to do so in these projects. For sodic soil it is recommended to apply gypsum (calcium sulfate) before sowing, but since the soil in these projects contains high levels of calcium as calcium carbonate, we decided to apply sulfuric acid which helps in releasing the calcium into the soil solution. The free calcium in the soil solution could then exchange with the sodium attached to the soil particles and release it into the soil solution to allow its leaching deeper into the soil.

Alfalfa plants often live in symbiosis with the Rhizobium bacteria, which forms nodules in its roots and fixes atmospheric nitrogen. However, in our projects in Torreon, because of soil conditions, there is very little nodulation, so our alfalfa is usually fertilized also with nitrogen (4-5 kg N/harvest).

Success!

Taking all the actions described above, alfalfa is grown and irrigated successfully by SDI even in challenging soil. Moreover, SDI has a big advantage in these conditions compared with sprinklers or

flood, since it allows to irrigate with high frequency (every 4 days), maintaining high soil water potential and achieving high quality alfalfa with tall and thin stems, that are low in fibers, and with wide leaves rich in proteins.

The fact that the soil surface remains dry, significantly reduces weeds which could compete with the alfalfa for water and nutrients and decrease the overall forage quality.

In the region of Torreon in the north of Mexico, alfalfa farmers were used to maintaining the alfalfa crop for only 2 years, with an average yield of about 20 tons of dry matter per hectare per year. With SDI we extended the life of the alfalfa crop up to 4 years till now, with yields of 25-30 tons/ha/year. The 30-50% of the water saved by drip irrigation was used to expand the cultivated area. The water use efficiency increased from 1.5 kg dry matter/m3 of water with flood irrigation, to 2.3 kg dry matter/m3 of water with drip.

The good results helped us expand our activity with Lala and reach 780 ha. Next year we are expecting to expand the Lala IAAS with another 1000-1200 ha.