THE CHOICE OF CROP ROTATION: AN IMPORTANT PARAMETER FOR CREATING AN ACCEPTABLE SALT BALANCE UNDER MINIMUM WATER USE[1]

F.W. Croon

Euroconsult bv, P.O. Box 441, 6800 AK Arnhem, The Netherlands

Introduction

The parameters for determining the optimum water management are the available water supply as compared to the crop water requirements, which in turn depend on the crop rotation. The drainage criteria also depend on the crop rotation, the irrigation supply, the irrigation water quality and the leaching fraction. This means that the choice of crop rotation has important implications for both irrigation and drainage management. This will be illustrated with an example from a project in Western China.

Drainage Project in Western China

The Xinjiang Pipe Drainage Project in Western China (Figure 1) has a continental climate; it is arid with an average rainfall of only 56 mm/year in summer. Due to the high number of sunshine hours in summer, the potential for crop production is high. The potential evapotranspiration is 1590 mm/year, of which the major part (1272 mm) is in summer in the growing season. In winter, everthing is frozen. The soil texture is sandy-loam to loamy-clay. Below 1.5 m -2 m , the subsoil is completely unstable.

The main problems encountered in the area include:

- **High ground water levels**, varying between 0.25- 2 m below field level. Irrigation in the area started somewhere in the 1950's and by the end of the 1980's the ground water level had already risen about 10 m;
- **Very saline groundwater** in places, with an electrical conductivity (*ECe*) of 5-100 dS/m, with the higher ranges being much more prevalent than the lower;
- **Secondary salinization** in the hot summer is considerable, especially after the harvest of the main crops in September/October before the frost sets in.
- **Water scarcity**. It is in a desert area so people want to irrigate the largest possible area.
- **Low quality irrigation water** with an *ECe* of 1.2-2 dS/m;

The above problems resulted in low crop yields and high water consumption. In solving these problems, we faced a number of constraints:

- Existing irrigation practices had to be maintained. Changing of these practices would have required adjustment of the irrigation infrastructure, which was not acceptable to our client;

[1] Text and figures are taken from the summary provided by Ir. Croon, a tape recording of his presentation, and some of the overheads used therein.

- There was no additional water available;
- It was practically impossible to construct deep open drains, basically because of the unstable subsoils.

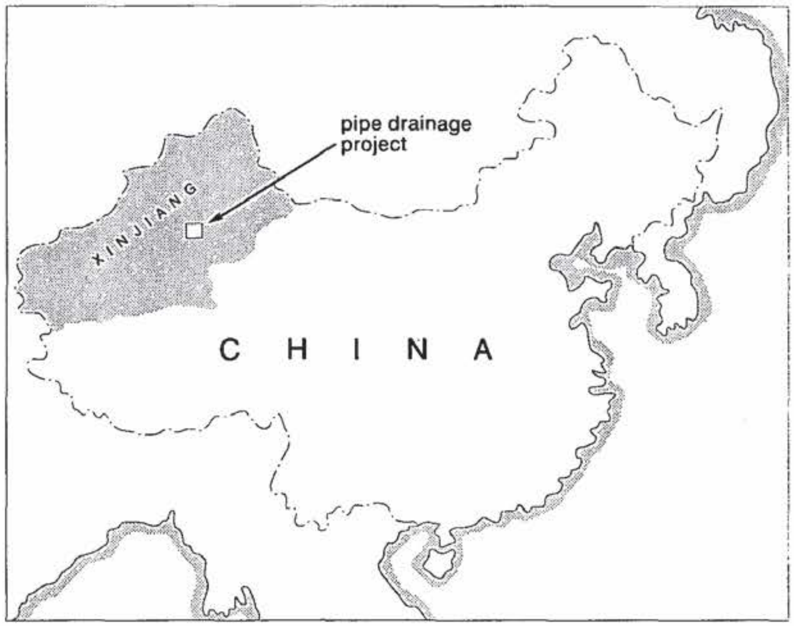

Figure 1. The Xinjiang Pipe Drainage Project in Western China

The only available option was the construction of a pipe drainage system, which could be installed, although with some difficulties, in the unstable soil at a depth of about 2 m. The design of the drainage system had to take into account the drainage water flow through the system as a design parameter. For determining this parameter, alternative salt and water balances were calculated for various crop rotations.

The traditional crop rotation was rice-cotton. Due to high water use by the rice crop (1800 mm net) this rotation resulted in scarcity of water and under-irrigation of the cotton crop (354 mm). The overall result is that salt accumulates in the top soil during the cotton crop and leaches out during the rice crop. Figure 2 presents the seasonal variation of the *ECe* under the traditional rice-cotton rotation. Please note that this is the situation **before** the installation of the drainage system.

Figure 2 shows a very high soil salinity during the cotton season, with the *ECe* going down during the rice season, and up again during the cotton season. The dip occurs when they started irrigating the cotton. Then, the *ECe* went somewhat down but after the harvest it went up again. Most of the secondary salinization took place in the months just before the frost sets in.

The installation of a pipe drainage system gave some scope for improvement:
- A possibility for leaching and lowering of the ground water table;
- Salinity control through drainage;
- Possibility to try out alternative cropping patterns;

- Reduced water use, because of less leaching requirements and less secondary salinization.

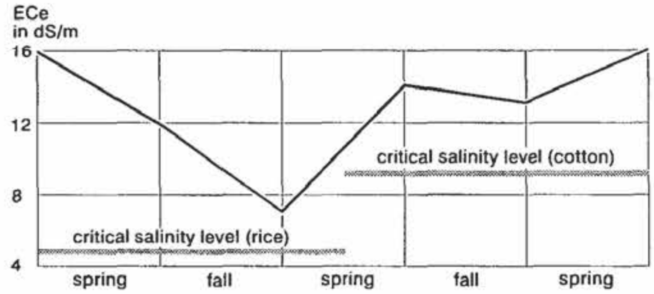

Figure 2. The seasonal variation of the ECe under the traditional rice-cotton rotation

Rice was - and this was mandatory by our client - to remain in the cropping pattern for economical reasons. We started, therefore, to evaluate the possibilities to vary the crop rotation with the existing infrastructure and irrigation practices. We considered about 13 crop rotations initially, and in the end did all the calculations for 7 rotations. The criteria we used for the selection of the crop rotations were:

- The highest possible income per ha and per m^3 of irrigation water;
- The lowest possible water use;
- The highest possible yield.

These are, of course, rather self-evident criteria, but it was quite difficult to match them. We arrived at the following solution. A six year rotation of one year rice, then one year wheat followed by sunflower as a green manure, then one year cotton. Then the salinity went up so much that we had to include a year with rice. After the rice, we had again cotton, for two years. With this rotation, we now have 33% of rice instead of 50%. This means a reduction of the crop with the highest water consumption.

The selected rotation gave the following results:

- The average water use was reduced to 93%. We had to grow sunflower as a green manure, which consumes quite a lot of water, but at a time when there is more water available;
- The average income per ha increased by 26%;
- The average income per m^3 of water increased by 40%;
- The average yield increased only 3%.

The salt balance with the chosen rotation (Figure 3) shows that during the growing seasons, one would have more or less acceptable *ECe* levels, with the exception of the wheat crop. The reason why the salinity level goes down after the wheat crop, is mainly because of the sunflower, which uses massive amounts of irrigation water.

During the first cotton season the *ECe* is quite good, during the rice season it is at acceptable levels, aterwards it rises again. But during the cotton seasons, during the critical stages of the crop, the soil salinity remains within acceptable levels.

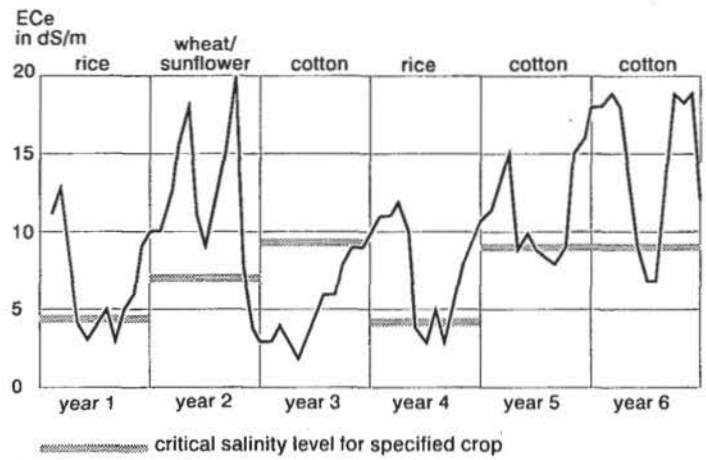

Figure 3.

This was the outcome obtained with the constraints mentioned earlier. In case the constraint of the irrigation infrastructure could be eliminated, irrigation for the dry-foot crops could be modified and increased, a crop rotation without rice is well feasible. In case of a rotation of cotton-wheat, water savings of 30-40% are attainable, while maintaining the *ECe* in the rootzone below 6-9 dS/m. Since the leaching is less dependent on peak flows during the rice growing period, the capacity of the drainage system could then also be reduced somewhat.

Conclusions

1. The introduction of a sub-surface drainage system (spacing 50 m, depth 2m) for salinity control in arid Western China created the potential for more effective water management and salinity control.
2. The crop rotation is an essential factor in determining the design and operation parameters for irrigation and drainage management as well as the overall water requirement for maintaining an acceptable salt balance.
3. Success depends on your ability to influence farmers to grow what you want them to grow. Under the conditions of a state farm in Western China, however, this was hardly a problem.

Discussion

Taking questions from the audience on crop rotations, the author discussed the problem of how to remove salts from the profile. In the applied crop rotation, extra water to remove salts was given to the cotton crop. A second point of discussion was the salt balance of the area. The author explained about the total salt load entering the area at the upstream side and the salts removed from the area, which were evacuated to desert evaporation ponds. Another question dealt with model simulations of this problem. The author mentioned that five year data was availale, which could be used for model calibration. On aspects of yields and income, the answer was that if farmers could grow more cotton their income would rise. The last question dealt with leaching of salts. The author explained that in between the cotton and wheat crops, salinization occurred, which was leached with extra water.