IRRIGATION OF 'BLACK' CLAYS IN MOZAMBIQUE

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General Background

MBB Consulting Engineers Inc (MBB) have been involved in the irrigation of so-called 'Black' or 'Delta' clays in Mozambique since 1997. The irrigation of these soils requires somewhat special techniques that incorporate modern technology with the oldest and simplest form of irrigation, flood or surface irrigation.

These soils are correctly termed vertisols and have a number of very specific characteristics that prevent effective irrigation by more conventional modern means such as sprinklers, centre pivots and other 'pipe-borne' irrigation systems. The primary reason for this is the very high swelling and shrinkage characteristics of these soils under the wetting and drying cycle. Linked to this is that the soils crack to considerable depth when dry and, due to their high clay content, are very slippery and have low bearing capacity when wet.

Because of the severe cracking mentioned above, the soils have a very high initial absorption capacity as the water enters the cracks. When the water has been taken up, the clay swells and the cracks close and, within 30 minutes to an hour, infiltration rates drop to virtually zero. When the soils are wet, water moves slowly within the profile due to the high clay content and the consequential adsorption of water to clay particles. As a result, a complete irrigation application is required during the high-uptake window, typically in the first 30 minutes to one hour. To attempt to apply this amount of water through modern irrigation methods is not practical. However, using surface irrigation, where water runs in furrows and fills the cracks quickly, a full application can be made. As the wetted furrow begins to seal, the water is forced to flow further down the furrow and a form of self-scheduling occurs. This sealing mechanism assists the designer of surface irrigation systems on these soils by controlling the contact time effectively and automatically, and allowing relatively flat grades to be used for the furrows.

MBB have been involved extensively in consulting with sugar estates in Mozambique to re-establish this form of irrigation. In the past, accurate surveying and land forming were time consuming, costly and not very accurate. By employing modern survey equipment, purpose-made computer programs and lazer controlled earthmoving equipment, MBB have been able to use modern technology to maximise efficiency and minimise development costs.

One of the primary requirements for growing crops on these soils is to allow excess water to run off the lands and prevent waterlogging. Land forming as described above ensures that excess rainfall and irrigation water is carried off the land and into drains. Further benefits are that field operations can recommence earlier in the dry season and sooner after unseasonal rainfall events than would be possible on land that had not been levelled. Crop yields are increased significantly due to reduced waterlogging and more efficient irrigation and, in sugarcane, can on occasions double from the typical 50 to 100 tons cane/year, given adequate management.

Keywords: irrigation, black clays, Delta clays, black cracking clays, furrow irrigation

Drainage plan
Prior to planning the irrigation of a specific field it is essential to carry out an overall drainage survey and prepare a plan for the farm or estate. Until the large drainage plan is implemented it is not possible to plan the drainage of a specific land with any confidence. A surface irrigation layout does as much for drainage as it does for irrigation and also allows better utilisation of rainfall, as ponding in low spots does not occur during the rainy season.

Contour survey
The survey is carried out using a target mounted on a tractor. It is thus necessary for both ploughing and discing of the land to be carried out prior to the survey to facilitate visibility of the target and provide a land surface that the tractor can traverse easily. Making use of a tractor-mounted target enables an 'averaging' effect, which effectively eliminates the effect of undulating micro-relief. Using a tracking theodolite, it is possible to complete the field survey and reduction of 20 hectares in about four hours.

Design of 'cut and fill' land forming
The downloading of the data and subsequent design of the 'best-fit' surface for a 20 hectare field can be completed in a further two hours. Commercial survey software is used to determine the optimum plane(s) for a given field.

A prerequisite for software is that it must be able to reduce the survey rapidly and then facilitate the calculation of cut and fill volumes for different designs. Some of the purpose-made software programs available are dedicated to the calculation of 'best-fit' parameters. However, experience has shown that there is little control over the decision making process in these programs, and results obtained from these 'black-box' systems are unreliable.

Using appropriate software, it is possible to select a design plane that results in the least volume of earth moved, which equates to the lowest cost. The volume of earth moved can be manipulated by changing the grades of the furrow direction or cross-slope, or the field can be divided into smaller units to reduce the distance of 'carry' from cut to fill. A compaction factor of 1,25 was generally necessary in practice to balance the cut to fill during operations. However, this is likely to depend on the soil type and moisture content. It is good practice to limit the depth of cut to reduce the exposure of subsoil and, in the areas where land forming has been carried out, cutting to a depth of no more than 250 mm was found to be the best practice.

Soil tilth and vegetable matter
The finer the tilth in the field being levelled, the more efficient the grading will be, resulting in less time being expended in a given area.

Where grass or other organic matter has recently been turned in to the soil, it will take considerably more time to complete the grading process, and the operation will be less efficient because of clogging of the scoop. Ideally, in the interest of breaking down the organic matter and achieving a fine tilth, land that is to be graded should be ploughed and disced well before forming commences.

Tail drains
In a furrow irrigation layout, it is essential to have tail drains that allow adequate contact time for the irrigation water at the ends of the rows, and also to allow rapid dispersal of stormwater from the lands to the main drainage system.

The tail drains should be cut on a flowing grade to spill into the main drainage system. This should be done before land forming, with the spoil from the drain being dumped on the land to be levelled. Not having to remove the spoil and dump it elsewhere will also reduce costs considerably.