LESSONS LEARNED IN THE ART OF LAYING OUT PERMANENT RAISED BEDS

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Introduction

The adoption of raised bed systems in dryland agricultural areas is in its infancy in Western Australia. In 1997, the first demonstration trials of any size were installed, following a successful trial in 1996 of a 2ha area. The five sites installed in 1997 range in size from 2ha to 16ha. Each is situated on a section of landscape that is effectively planar. None of the difficulties of laying out a system of permanent raised beds on slopes which vary in three dimensions was encountered.

Whilst the avoidance of such complexities was deliberate in our first year, we were aware that such challenges had to be confronted and, if possible, solved in advance through the formulation of strategies to overcome them. The experience of Victorian and Queensland dryland farmers has helped in both regards.

We had hoped to enlarge our program in 1998 to include realistically large areas (>50ha) in three contrasting landscape-soil type-rainfall regimes. These were to be at Toolibin east of Narrogin, on a flat (<1% slope), waterlog-prone ancient floodplain, at Coyrecup east of Katanning, on a convex hilltop with varying slope (1-3%), and at South Stirlings, north east of Albany on a subtlely convoluted but flat landscape(<1% - 2%). Clearing roots and stumps from the first and waterlogging at the last of these sites allowed only the Toolibin site to be installed in 1998. This paper records the lessons learned from our experience at Toolibin.

Principles

Whilst effectively embarking on a process of learning-by-doing, we identified a number of principles to guide what was to be done and how it would be done. These are:

1. The layout of beds and associated drains, waterways and dams must allow farming operations to be done with ease, and the maximum possible proportion of croppable land should be retained.

2. Furrows between beds should always drain: They should not pond water.

3. Wherever possible, cross-drains installed to remove water from localised hollows should be contained within the area of raised beds by emptying them into other furrows lower in the catchment. The furrows between raised beds should be used as a network of safe disposal channels.

4. Any drains built to conduct runoff and drainage should be of sufficient capacity to drain the water they catch at a velocity equal to or greater than the that of inflow from furrows and drains leading into them.

5. Drainage water should, wherever possible, be stored for re-use on the land/property from which it came.

6. Any drainage water leaving the area/property should remain in the catchment from which it originates.

7. Ideally, the number of beds constructed should be equal a number of complete passes of seeding, spraying and harvesting equipment.

Lessons learned

Surveying

Beds and drains need to be laid out on the existing land surface

Given the reality in WA that topsoils are shallow and the subsoils are dense, impermeable and dispersible, landplaining would expose too large an area of this infertile soil. It would be too costly and counter-productive. The best strategy is therefore to rip to a common depth (20 cm) and mix the topsoil with any subsoil brought up in this operation. This is more likely to enhance the properties of the mixed layer over those of the separate layers.

Furrows need to drain completely

As the intent of permanent raised beds is to prevent waterlogging, it is necessary to ensure the furrows drain completely. Ponding in the furrows will create or illustrate the presence of a perched water table at the same height within the beds. When soil saturates it has no strength. It collapses under its own weight. The consequence of ponding in furrows will thus be slumped beds which have none of the macroporosity required for them to drain and aerate. Slumped beds will therefore be ineffective in preventing waterlogging.

Surveying needs to be intensive and accurate

Surveying needs to be undertaken at an intensity which ensures any minor changes in slope direction are detected (i.e. elevation changes of ≤ 10 cm). A contour map generated with this amount of detail will identify the need and best location for cross-drains.

Intensive and accurate surveys should be sufficient to plot at least 10 cm contours. Our experience at Toolibin required the intensity of a 50m x 20m grid. We used a differential Global Positioning System (GPS) and a laser level. This equipment is probably the least sophisticated technology capable of undertaking the task at a reasonable cost. More sophisticated survey equipment, such as a GPS-Glonass surveying system can be bought for around \$ 70,000 or hired for a fee of \$ 500/day, and this includes software to print detailed contour maps. Our survey data were put into a mapping program which produced a map with 5cm contours (Figure 1.).

Orientation of Raised Beds

Landscape slope direction Vs that which is operationally efficient

Because the landscape slope at Toolibin runs East to West and the paddock has a large open drain on the southern and western boundaries (Figure 1.), the obvious choice for the direction of the beds was E-W. This would ensure the machinery passes were long and the amount of turning was minimal.

However, with a slope of 0.14% the greater concern was the removal of water. The low slope dictated that the raised beds be orientated in the direction of the landscape slope, which ,fortuitously, was also E-W. This orientation also ensured the beds and furrows required only a small amount of cross drainage.

Had the considerations of operational efficiency and drainage direction been in conflict, consultation with the farmer would probably have resulted in a decision in favour of operational efficiency. Operationally inefficient layouts of raised beds will raise input costs every time a paddock is cropped, whereas any extra drainage costs incurred to maximise operational efficiency will be incurred only once.

Drain installation

Drains need to be installed first

In the Western Australian conditions of shallow topsoils and clayey and infertile subsoils, the installation of drains before any preparatory work is done for raised beds provides the opportunity for spoil from drain excavation to be spread and cultivated into the ripped and cultivated soil that will form the raised beds. Such homogenisation diminishes the risk of particularly unproductive areas of subsoil spoil causing poor plant growth which would make beds less effective than they would otherwise be.

Drains need to be in a form compatible with machinery and erosion control

a) Cross drains within raised bed runs

Good drain design and construction dictates the *batters of drains have slopes of ≤ 1:6.* This ensures that machinery can drive through them easily and they can grow crop or pasture without an excessive risk of erosion. Our experience is that a batter grade should not exceed this slope. With a drain depth of 40 cm, a need for which can easily arise, the slope length of a 1:6 batter is 2.43m, which is less than the length of a tractor let alone one with a toolbar on its 3-point linkage.

Good drain design and construction also dictate the channel floor be wide in order to provide a large flow capacity at non-erosive velocities. In addition, ease, and thus quality, of machinery operation dictates the *channel width should be about the length of a tractor wheel base, i.e. 3m.*

Drains at angles other than 90° to the direction of the beds cause pitch and roll of machinery, particularly 3-point linkage equipment.. This phenomenon is further exacerbated if the drains have a triangular cross-section (i.e. a narrow channel floor). In our case, the weight and width the furrower-bed-former and seeder bars, both of which are carried on 3-point linkage, means the elimination of pitch and roll as machinery enters drains is essential to minimise machinery maintenance and maintain good operational standards. *Drains should be oriented at or close to an angle of 90 ° to the direction of beds.*

b) Drains at the end of raised beds

The same lessons apply at the ends of raised beds as for drains within beds. However, other considerations come into play here. The end of beds become headlands on which all farm traffic must turn or operate. These headlands need to be wide enough for machinery used for bed construction, seeding, spraying and harvesting to easily turn and operate. At the upslope end of the beds there may not be a drain, in which case only turning space considerations are relevant. At the downslope end drains need to have at least the minimum requirements mentioned above, with some enlargement in flow capacity to carry the accumulated outflow of furrows and/or feeder drains. *The width of the channel floor and batters of end-drains should be compatible with the width of seeder, boom sprays and harvesters*, so crops can be easily grown on them.

Conclusions

- Accurate contour maps, with contours at 5cm or 10cm vertical intervals, are a prerequisite for achieving operational efficiency and effective layouts of raised beds to drain waterlog-prone land.
- Operationally efficient areas of raised beds require: smart drain location; hydraulic design of drains which accounts for machinery dimensions; orientation of drains at angles close to 90°to the direction of beds; and good earthwork construction standards.

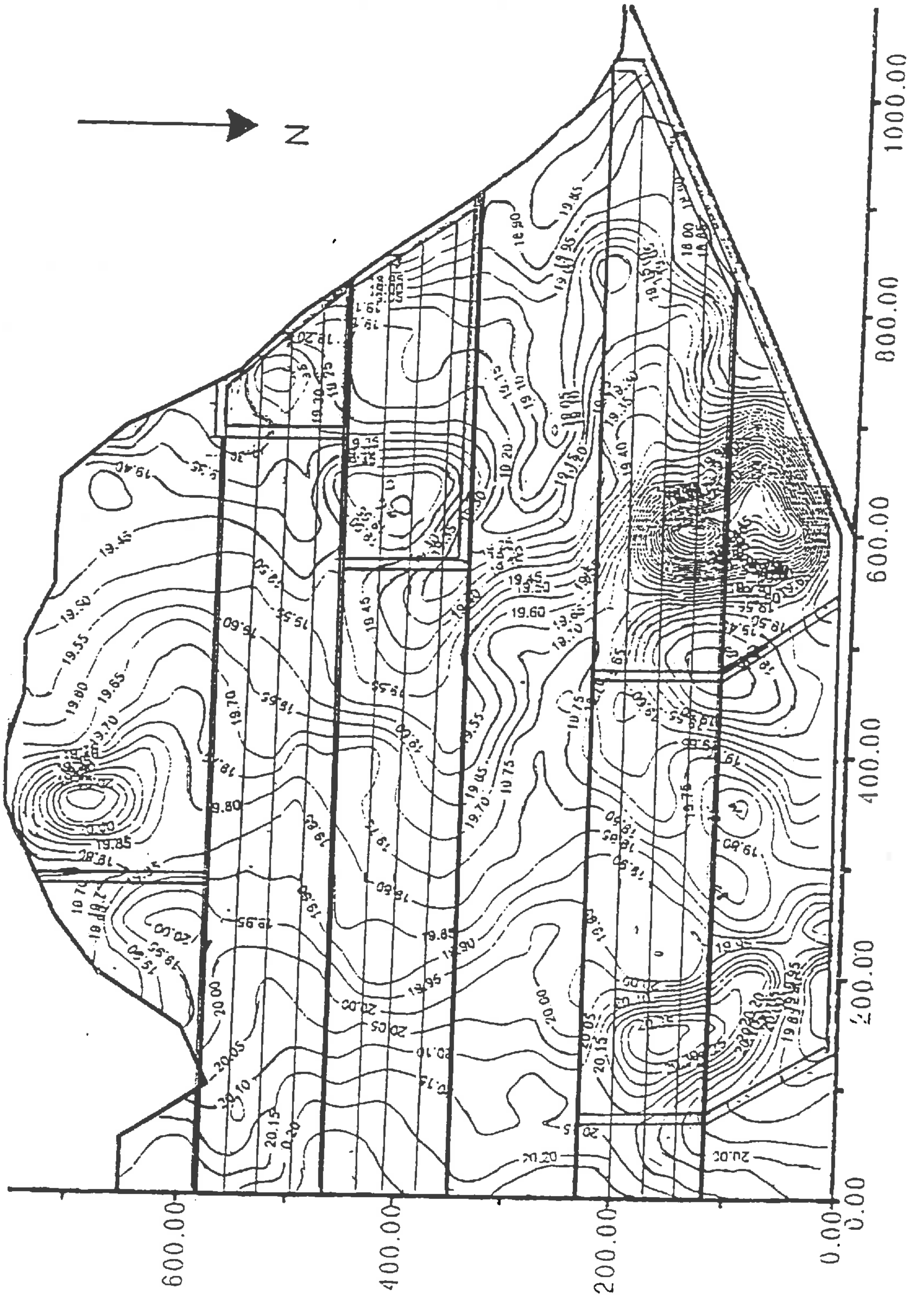

Figure 1. Contour map of the Raised Bed demonstration at Toolibin. Note the low slope and the cross-drains at angles approaching 90° to the direction of the beds. Major collection drains run along the northern and southern edges and join to leave the paddock in the north west corner.