2000

Raised beds prevent waterlogging and increase productivity

Greg Hamilton
Derek Bakker
David Houlebrook
Cliff Spann

Follow this and additional works at: https://researchlibrary.agric.wa.gov.au/journal_agriculture4

Part of the Agronomy and Crop Sciences Commons

Recommended Citation
Hamilton, Greg; Bakker, Derek; Houlebrook, David; and Spann, Cliff (2000) "Raised beds prevent waterlogging and increase productivity," Journal of the Department of Agriculture, Western Australia, Series 4: Vol. 41 : No. 1 , Article 2.
Available at: https://researchlibrary.agric.wa.gov.au/journal_agriculture4/vol41/iss1/2

This article is brought to you for free and open access by Research Library. It has been accepted for inclusion in Journal of the Department of Agriculture, Western Australia, Series 4 by an authorized administrator of Research Library. For more information, please contact jennifer.heathcote@agric.wa.gov.au, sandra.papenfus@agric.wa.gov.au, paul.orange@dpird.wa.gov.au.
Raised beds prevent waterlogging and increase productivity

Cover Page Footnote
The project is jointly funded by the Grains Research and Development Corporation; Agriculture Western Australia; machinery manufacturers Gessners Ltd and Simplicity Australia from Queensland, and Walkers from Merredin in Western Australia; and seven collaborating farmers from Quairading to South Stirlings.
Raised Beds Prevent Waterlogging and Increase Productivity

Permanent Raised Beds are proving to be a revolutionary means of preventing waterlogging and substantially increasing the productivity of wet and poorly productive land in Western Australia. In just three years, a research project has seen significant improvements in yield and reductions in waterlogging. The project is jointly funded by the Grains Research and Development Corporation; Agriculture Western Australia; machinery manufacturers Gessners Ltd and Simplicity Australia from Queensland, and Walkers from Merredin in Western Australia; and seven collaborating farmers from Quairading to South Stirlings. Greg Hamilton, Derk Bakker, David Houlebrook and Cliff Spann report on the research project and its outcomes to date.

Outcomes from the research project have been significant, including:

• Yield increases of between 0.3 tonnes per hectare and 0.93 tonnes per hectare in cereals, pulses and oilseeds on research sites as widely spread as Beverley, South Stirlings and Esperance.

• Eliminating waterlogging in the root zone of crops.

• Harvesting about four per cent more of the seasonal (May to October) rainfall as run-off and drainage in wet years.

• Reducing run-off by about four per cent of the seasonal rainfall in dry years.

• Reducing the percolation of water into the ground water system in wet seasons.

Raised Bed farming has already been adopted by farmers in the Esperance, Albany, Scott River, Woodanilling and Tambellup districts, with a total area cropped of around 6,000 hectares. Most significantly, Raised Bed Farming has given these farmers equal or bigger yield increases than those achieved by the research team.

How big a problem is waterlogging?

Western Australia's agricultural lands are particularly prone to waterlogging. Computer modelling indicates the area of land susceptible to waterlogging is at least about two million hectares (see Figure 1). A large proportion of the 1.8 million hectares of salt-affected land, with its shallow water tables, can of course be added to this estimate.

The impact of waterlogging on crop production is most severe when it occurs in August. Studies of grain receivals and rainfall have shown that August waterlogging can reduce the crop production of Shires by as much as 25 per cent. Farmers with waterlogged land know their losses can be up to 100 per cent in the worst affected areas. Conservative estimates of the cost of waterlogging in terms of 'lost' production amount to $90 million per annum.

How do Raised Beds work?

Raised Beds are engineered to create a root zone which is about 30 centimetres deep with a stable structure and a low density. The tops of the beds are about 1.4 metres wide, with furrows on either side that are about 0.45 metres wide. The furrows serve primarily as drains and traffic lanes, although to date the

Figure 1 – Map of lines of equal waterlogging frequency in July for the lower half of the agriculture area of WA. Note the vast area of land where shallow loam-over-clay soils would be subject to waterlogging for more than 40% of the year.
furrows have also been planted with crops. The dimensions, stability and low density of raised beds ensure they rapidly absorb rain, drain excess soil-water and aerate (see Figure 2). Excess soil-water drains sideways from the beds into the furrows and from there it flows into catch-drains, waterways and dams or rivers.

The most critical factor affecting the success of raised beds is the speed with which the soil aerates after periods of wetness. A generally accepted criterion for the prevention of waterlogging is that soil requires about eight per cent of its volume air-filled and connected to the atmosphere. Saturated soil has about three per cent of its volume air-filled, so to prevent waterlogging another five per cent of air-filled pore space has to be created and maintained.

Drainage theory, using a 'time-to-drain' criterion of two days to lower a water table, illustrates that if a soil has good hydraulic and aeration properties, the width of Raised Beds could be as great as about four metres. A soil with poor hydraulic and aeration properties on the other hand requires much narrower beds for the water table to fall in this time.

For practical and economic purposes, the spacing of beds is recommended to match the track width of tractors and harvesters. We use 1.83 metres (or six feet) centre-to-centre bed spacings. This is a common trackwidth of tractors, and the trackwidth of harvesters is effectively double this, 3.66 metres (or 12 feet).

Long-term maintenance of drainage and aeration properties in raised beds will depend on:

- The use of no-till crop establishment with minimum soil disturbance and maximum root retention between crops.
- Complete avoidance of compaction by farm machinery and, preferably, animals.
- Avoidance of ponding in the furrows (ponded furrows will saturate the base of the beds and cause them to slump and lose their drainage and aeration properties).

Location of Raised Bed (RB) experimental sites

The Raised Bed research is being undertaken at a paddock scale on farmers' properties across a wide sweep of the southern agricultural area, ranging from Quairading to Beverley, South Stirlings and across to Esperance. The size of these sites ranges from five hectares to 64 hectares.

Production increases

The freely drained and aerated root zone engineered in Raised Beds is at least three times deeper than that found in normal seedbeds. It has the ability to: (i) absorb more rain; (ii) store more plant-available water; (iii) drain excess soil-water; and (iv) conserve more water than a normal seedbed. With these characteristics, Raised Beds are expected to be more productive.

In the research project, the measured yield increases (see Table 1) were consistent with observations and measurements made of improved mid-season growth (see Images 1 and 2).

Of the eight sets of data listed in Table 1 as having 'in-crop problems', six occurred in 1998 because of problems with seeding depth (see section on page 7 on Special challenges of farming Raised Beds). Poor seeding depth control in 1998 was the result of design failings in the disc seeder used and a low load-bearing capacity of moist, loose soil in the Raised Beds.

The other two sets of 'problem' data were caused by inadequate control of weeds, diseases and insects.

The production data that realistically reflected the productivity of Raised Beds are those
<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Crop</th>
<th>No in-crop problems (t/ha) (%)</th>
<th>In-crop problems (t/ha) (%)</th>
<th>Explanation of management problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quairading</td>
<td>1998</td>
<td>Barley</td>
<td></td>
<td>0.16 (8%)</td>
<td>• Deep seed depth, poor establishment</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>No crop</td>
<td></td>
<td></td>
<td>• Too wet from summer rain</td>
</tr>
<tr>
<td>Beverley</td>
<td>1997</td>
<td>Oats</td>
<td>0.32 (26%)</td>
<td>-0.04 (-4%)</td>
<td>• Deep seed depth, poor establishment</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>Canola</td>
<td></td>
<td></td>
<td>Reseeded</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>Peas</td>
<td>0.57 (41%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toolibin</td>
<td>1998</td>
<td>Oats</td>
<td>0.19 (10%)</td>
<td></td>
<td>• Deep seed depth, poor establishment</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>Canola</td>
<td>0.16 (14%)</td>
<td></td>
<td>Large weed population on RBs</td>
</tr>
<tr>
<td>Woodanilling</td>
<td>1997</td>
<td>Oats</td>
<td>0.80 (47%)</td>
<td></td>
<td>• Deep seed depth, poor establishment</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>Canola</td>
<td>0.22 (32%)</td>
<td></td>
<td>Reseeded Late harvest</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>Peas</td>
<td>0.44 (43%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badgebup</td>
<td>1999</td>
<td>Canola</td>
<td>-0.07 (-4%)</td>
<td></td>
<td>• No Impact® on 2 RB replicates</td>
</tr>
<tr>
<td>Cranbrook</td>
<td>1997</td>
<td>Oats</td>
<td>0.50 (22%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>Canola</td>
<td>0.40 (33%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>Wheat</td>
<td>0.53 (28%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mount Barker</td>
<td>1996</td>
<td>Barley</td>
<td>0.72 (49%)</td>
<td></td>
<td>• Harvester error</td>
</tr>
<tr>
<td></td>
<td>1997</td>
<td>Oats</td>
<td>unreliable data</td>
<td></td>
<td>• Deep seed depth, poor establishment</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>Wheat</td>
<td>0.17 (9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>Canola</td>
<td>0.25 (13%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Stirlings</td>
<td>1999</td>
<td>Wheat</td>
<td>0.47 (16%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esperance</td>
<td>1997</td>
<td>Oats</td>
<td>0.80 (33%)</td>
<td></td>
<td>• Deep seed depth, poor establishment</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>Canola</td>
<td>0.10 (5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>Wheat</td>
<td>0.93 (34%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average yield</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.56 (32%)</td>
<td>0.11 (9%)</td>
</tr>
<tr>
<td><strong>Overall (incl. problems)</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.38 (23%)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 – Production increases measured from crops grown on Raised Beds with and without in-crop problems (t/ha and % increase on normal seedbed yields).

obtained without the adverse impact of seeder inadequacies or in-crop management difficulties. These data showed an average increase of more than 0.5 tonnes per hectare of grain across a range of crops, seasonal conditions and soil types. This average increase is very robust.

Resource conservation benefits of Raised Bed Farming

**Surface water**

Raised Beds are installed up-and-down the slope to ensure furrows drain all excess water
from the site. Theoretically, paddocks of Raised Beds will shed more water in wet seasons than a normal seedbed, as some rain will not be absorbed by the furrows and excess soil-water will drain from the beds.

In seasons that are drier, or those that have no or few large or prolonged rain events, the run-off from a normal seedbed surface is more likely to equal or exceed that of Raised Beds. In such seasons, the surface soil of Raised Beds will remain drier than a normal seedbed due to their increased infiltration capacity. Only the 25 per cent of the area that is furrows is likely to occasionally shed water during the drier seasons.

Table 2 data illustrate the potential Raised Beds have for harvesting water in the Western Australian environment, particularly if the run-off water is directed into on-farm storage dams. For example, 10 millimetres of run-off from an area of 100 hectares amounts to 10,000m$^3$ of water. When comparing the run-off recorded in 1998 (see Table 2), 63%, 35% and 125% more water ran off the Raised Beds than from the control areas at Cranbrook, Mount Barker and Esperance, respectively.

The installation of catch drains and waterways is an essential component of Raised Bed farming. They ensure the removal and safe disposal of excess water. If storage dams are
added, the potential for water conservation and its alternative use can be realised.

**Drainage beyond the root zone**

Drainage beyond the root zone of crops mostly leads to recharge of the groundwater system. This causes water tables to rise and salinity to worsen. However, Raised Beds, by virtue of their ability to drain excess water from the root zone of plants, have the potential to limit or even prevent drainage beyond the root zones of crops and pasture. In fact, data from the Cranbrook site in 1998 showed that a reduction in deep drainage had been achieved beneath the Raised Beds.

In summary, the careful application of Raised Beds to waterlogged and saline land is likely to:

- Eliminate waterlogging and avoid the harmful interaction of waterlogging and salinity.
- Leach salt from the root zone of crops and pastures.
- Reduce capillary rise of salt from the water table.
- Reduce on-site recharge of shallow water tables.
- Produce profitable crops and pastures.

**Special challenges of farming Raised Beds**

**Weed control in new Raised Beds**

The most substantial challenge with Raised Bed farming is the excessive weed establishment in the first season after their installation. The soil disturbance required for their formation stimulates the establishment of weeds.

However, once Raised Beds are established and a good crop rotation is imposed, the range of herbicides required enables weed control to be quickly re-established. A sensible first crop on Raised Beds in a soil where a large grass seed burden may be present is Triazine-tolerant canola.

**Seeding Raised Beds**

Raised Beds are soft with little load-bearing capacity, particularly when moist. Seeder openers need to have good flotation to avoid penetrating too deeply. Raised Beds also often have a varying height and profile. Seeders need to have openers that can independently follow variations in the height of raised beds (see Image 3).

Notwithstanding this requirement, many early adopters of Raised Bed farming have successfully used tined seeders that do not have the capacity for individual tines to follow the seedbed surface. The use of these machines on Raised Beds does, however, require very careful and competent operation to achieve reasonable uniformity in the depth of seeding and to establish adequate crops.

**Machinery requirements of Raised Beds**

The machinery requirements for installing and operating a system of Raised Beds are not great. Only one specialised piece of machinery is required. The remainder can be adapted without great difficulty or expense.

The single item of specialised equipment required is the furrower-bed former (see Image 4). This can be either a three-point linkage or towed item. The price of bed-formers depends on the size. A one and two
half-bed machine is likely to cost about $10,000 to $15,000. A three and two half-bed machine will cost between $20,000 and $30,000.

Tractors need to have single rear wheels with 45-centimetre-wide tyres and a track width of 1.83 metres.

It is preferable that tractors be front-wheel-assist types. Seeders, sprayers, swathers and harvesters need to have track widths and tyre sizes compatible with the spacing and width of furrows (see Image 5). The cost of adapting seeders, sprayers and swathers is not great. The cost of adapting a harvester will be about $12,000.

Farmers should realise that machinery adapted to farm Raised Beds remains entirely suitable for broadacre farming requirements.

**Economics of Raised Beds**

Given the production increases that have been obtained from Raised Beds in this research project, any farmer adopting them should gain a rapid return on investment and considerably increased cropping profitability. An indication of the extra income generated from Raised Bed farming is obtained by converting to dollars the yield increases of Table 1, using current commodity prices taken from the Farm Budget Guide 2000 (see Table 3).

**Future developments**

*Seeding only the beds*

Measurements of the comparative productivity of the Raised Beds and furrows reveal that the beds are three times more productive than the furrows. Currently, two rows of crops are sown in every furrow, and five rows are sown on every Raised Bed (with row spacing of 26 centimetres). The furrows therefore receive 28 per cent of the seed and fertiliser inputs (i.e. two rows out of seven rows), but contribute only 12 per cent to the overall yield.

In future, consideration will be given to placing all the seed and fertiliser on the Raised Beds. This will probably produce a better yield and return on investment, as all inputs will be placed in a more productive environment. In addition, avoiding placing fertiliser in the furrow will lessen the risk of nutrients being transported off-farm and polluting waterways.
**Application of Raised Beds to salt-affected land**

In principle, Raised Beds have the properties to prevent waterlogging, enhance the leaching of salts from the root zone of crops and reduce on-site recharge of the groundwater. Plans have been made to research the application of this technology to salt-affected land. Farmers at Quairading and Dumbleyung have already installed Raised Beds on salt-affected land, and crop production, soil-water and salt content data will be collected over the next few years. The Grains Research and Development Corporation (GRDC) is considering a Research Proposal to develop this potential.

---

### Table 3 - Average extra income generated by yield increases on Raised Beds (see Table 2) for specific crop types.

<table>
<thead>
<tr>
<th>Crop type and Commodity price</th>
<th>Extra income from crops with no problems</th>
<th>Extra income from all crops grown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats (@ $110/t)</td>
<td>$66/ha</td>
<td>$57/ha</td>
</tr>
<tr>
<td>Barley (@ $160/t)</td>
<td>$115/ha</td>
<td>$70/ha</td>
</tr>
<tr>
<td>Canola (@ $350/t)</td>
<td>$116/ha</td>
<td>$60/ha</td>
</tr>
<tr>
<td>Wheat (@ $180/t)</td>
<td>$115/ha</td>
<td>$95/ha</td>
</tr>
<tr>
<td>Peas (@ $210/t)</td>
<td>$105/ha</td>
<td>$105/ha</td>
</tr>
<tr>
<td><strong>Average extra income</strong></td>
<td><strong>$104/ha</strong></td>
<td><strong>$77/ha</strong></td>
</tr>
</tbody>
</table>

---

**Image 6.**

*Aerial view showing how Raised Beds were able to prevent waterlogging in oats at Cranbrook in 1997. Note the difference between Raised Beds and Control treatments. Also note the effects of waterlogging in a barley crop, which can be seen in the paddock up-slope of the experimental area (property of Warwick Armstrong). (Left)*