Options for root zone drainage in high rainfall areas.

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Abstract

Many areas in Australia experience from time to time wet conditions, which can lead to waterlogging and limited the yield. Research in the use of raised bed to combat waterlogging demonstrated an average increase in productivity of about 10-15% in most years. However certain aspects associated with raised beds could hamper the adoption of the raised beds. In addressing some of these issues other options such as wide-spaced furrows and ridge seeding are being investigated.

The wide-spaced furrows are a derivative of common raised beds but with larger furrow spacing. Properly working beds drain water quickly which depend on the hydraulic conductivity and gradient in the soil. Results from actual measurements of the hydraulic conductivity of the topsoil used in drainage calculations suggested that a furrow spacing of 6m would still provide sufficient internal drainage. Results in 2005 using a biomass image and a yield map from a site are indeed indicating that wide-spaced furrows are adequate to reduce the waterlogging significantly.

Ridge seeding is an alternative method of furrow seeding is currently being tested, placing the seed on the edge of a ridge adjacent to the furrow rather than in the seed furrow. The ridges are made using a specially modified tyne, that looks like a wedge with two wings. The results in 2005 have been interesting but several issues need to be investigated further.

Key Words

Waterlogging, raised beds, cereals, furrows, ridges

Introduction

Many areas in Australia experience wet conditions from time to time, which can lead to waterlogging and affect the yield (Zhang *et al*, 2006). Over the last 8 years research in the use of raised bed to combat waterlogging demonstrated an average increase in productivity of about 10-15% in most years (Bakker *et al*, 2005). However several issues are associated with raised beds that might limit the adoption of raised beds as a farming system. These are: i) the need to match wheel spacing to furrow spacing on all vehicles working raised bed paddocks, ii) stock trapped in furrows, iii) difficult vehicle access to raised bed paddocks, iv) requirement of special bed forming equipment and v) awkward implementation in paddocks with many physical obstacles such as trees and rocks. Other methods to reduce the effects of waterlogging such as wide-spaced furrows and, possibly, ridge seeding would address some of those issues. These are currently investigated and some results presented in this paper.

Wide-spaced furrows

To combat waterlogging, raised beds have been researched, among others, by the Department of Agriculture and Food of Western Australia (DAFWA). The DAFWA approach is based on a furrow spacing of 1.83 m which is the wheel spacing of the tractor making the beds and seeding them rather than on drainage considerations (Bakker *et al* 2005). For beds to work properly they need to drain water quickly (i.e. 24 hrs) which depend on the hydraulic conductivity (ease of water flow) of the soil and the hydraulic gradient (driving force of the water flow) in the soil. The first depends on the soil type and structure while the latter depends on the depth of the furrow and the distance between the furrows.

In WA the low hydraulic conductivity of the subsoil rather than the topsoil is the main contributing factor to waterlogging on duplex soils. The conductivity of the topsoil is usually good, provided the soil structure has not deteriorated too much. Therefore the furrows which are located in the topsoil can be spaced more than 1.83 m apart and still provide enough internal drainage. This is illustrated in Figure 1 for two soil types with two different hydraulic conductivities (Ks) and a furrow depth of 25 cm.

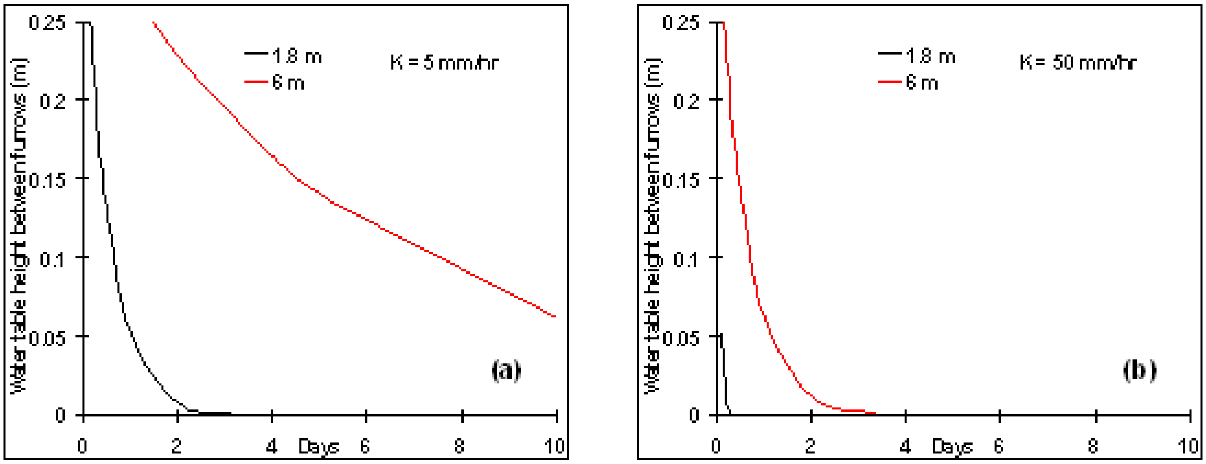

Figure 1. Drop in the perched water table over time in the middle between two furrows (depth = 25 cm) for two bed widths (1.8 m and 6 m) and two hydraulic conductivities (Ks) of the topsoil: 5 (a) and 50 mm/hr (b).

Measurements of the topsoil at different locations indicated a Ks ranging from 50 – 100 mm/hr which would suggest that a furrow spacing of 6m would still provide sufficient internal drainage such that within 1 day the water table in the middle between the furrows drops to 12 cm below the soil surface.

A furrow spacing of, for example, 6m would allow vehicles and equipment to utilise the beds without making any modifications. In fact the furrow spacing can be, for example, such that it matches half the width of the seeder bar, the furrow in the middle is then used for tracking with two furrows on the extremities of the seeder bar. The wheel tracks are cropped as normal. When the traffic, which does not occur in the furrows is restricted to traffic zones, a tramline system with intensive surface drainage is established.

Method

At two sites: North Stirling and Woodanilling, sown to canola and barley respectively, wide-spaced furrows (WSF) were implemented in 2005 and compared to raised beds (RB) and a normal undrained seed bed (Control). The furrows were made using a small three-point linkage frame carrying one Gessner furrower, see Figure 2. The raised beds were formed with a Gessner bedformer. Seeding of the WSF and the Control was done in early May with seeders used by the farmer while the raised beds were sown with the custom-made raised bed seeder from DAFWA.

Figure 2 Rear view of the furrower.

The crop biomass was estimated from a digital multi-spectral image (DMSI) taken before flowering and the yield was obtained from grain/plot weights combined with yield mapping information.

Results and Discussion

The results from North Stirling will be presented. After 230 mm of rain in April, May and June extensive damage from waterlogging occurred in the Control. Areas dissected by WSF or RB were 'puddle-free' with a good crop establishment between the furrows. The DMSI in the beginning of August, prior to flowering of the canola is presented in Figure 3.

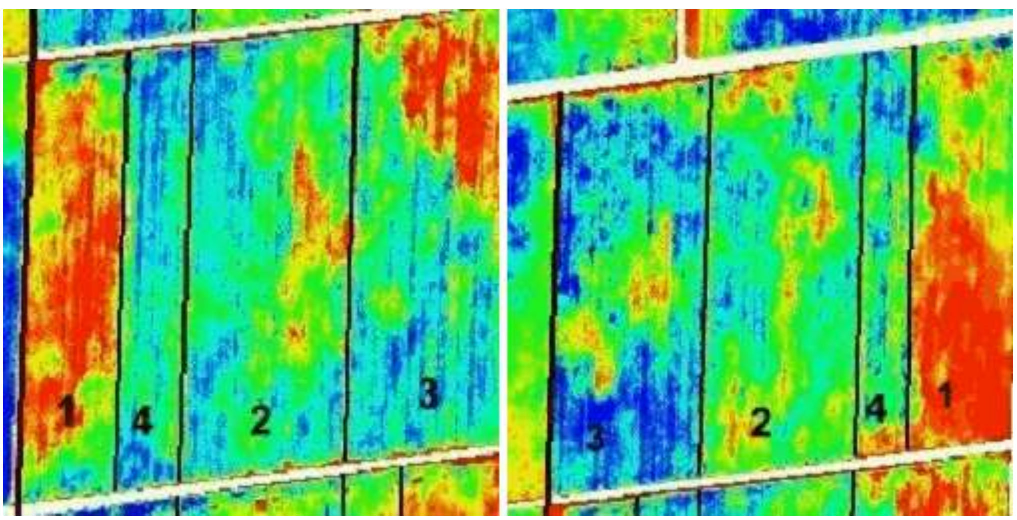

Figure 3 Biomass images of surface water management treatments.1 = Control, 2 = RB without renovation, 3 = RB with renovation) and 4 = WSF. Lighter dark grey = Lowest biomass, Light grey = Medium biomass and Dark grey = Highest biomass

Figure 3 clearly illustrates the effect of the WSF and the RB. The WSF were installed in sections of the Control plots (1) and a clear distinction between the areas can be made where the WSF (4) were implemented. The RB (3) had the highest biomass due to the deeper furrows and a loosened top soil this was reflected in the yield. The final yield at North Stirling is presented in Table 1.

Table 1. Canola grain yield (T/ha) from the North Stirling site in 2005

Plot	RB	WSF	Control
1	1.56	1.00	0.62
2	1.16	1.31	1.12
3	1.35	0.72	0.59
4	1.17	1.28	0.95
Mean	1.31	1.08	0.82

LSD (P=0.05) = 0.39 t/ha

The renovation of the RB which included loosening of the soil as well as cleaning out and deepening the furrows increased the yield compared to the Control while implementing WSF in the Control areas significantly improved the yield from those areas.

At Woodanilling the barley yield in all the treatments was affected by a severe frost in September and yielded very little (i.e. 0.49 t/ha) with very small treatment differences.

A system like the WSF, while not as a productive as raised beds, appears to be effective in removing excess water, is cheaper to implement than raised beds, does not require altering of any machinery, creates only some obstructions to traffic, substantially reduces the chance for livestock to get trapped in the furrows and is ideally suited to be included in a tramline farming system. In dry years the impact of this system would mainly be expressed through a slight reduction in area seeded even though in dry years there's always a chance that waterlogging events occur.

Ridge Seeding

Another possible method to combat the effects of waterlogging has been tested in 2005 at the Mt Barker Research Station and is called 'ridge-seeding'. Normally seeds are placed in seed furrows, created with a tyne and then pressed with a press wheel. The seeds are thus placed in the wettest part of the topsoil which can be beneficial when moisture needs to be captured to get the crop started. However the plant is most susceptible to waterlogging at seed germination and the seedling stage up to tillering (for cereals). In areas prone to waterlogging it might therefore be more beneficial to place the seeds on a ridge adjacent to the furrow rather than in the furrow. The seedling can then develop in a well-drained ridge reducing the impact of waterlogging. Waterlogging later in the season is less of an issue. Also no area is 'lost' to furrows such as in raised beds or WSF.

Method

The trial consisted of three treatments, ridge seeding, raised beds and normal seedbed, using 2 types of wheat, Camm and Wyalkatchem, which were sown on the 17^{th} of June, just before the onset of a dry period. The ridges were made using a modified tyne that resembled a wedge with two wings pulled through the topsoil, making a small furrow and a ridge on either side of the furrow. The seed was placed in the loose soil on the side of the ridge with disc seeder units. Each plot was 1.8 m wide and 30 m long. Fertilisers, MAP (70 kg/ha) and urea (50 kg/ha) were applied at seeding time as well as some urea (50 kg/ha) in late July.

Results and discussion

Some crop productivity results and soil properties are presented in Table 2.

Table 2 Soil bulk density, dry matter production and yield at the MBRS ridge seeding trial in 2005.

Treatment	Soil bulk density (Mg/m^3) in seed row	Dry matter (5 Aug) (T/ha)	Dry matter (30 Sept) (T/ha)	Yield (T/ha)	
				Camm	Wyalkatchem
Control	1.19	0.20	6.25	3.60	3.27
Ridge	1.00	0.35	7.57	3.61	2.99
Raised beds	1.22	0.23	5.93	2.99	2.67

The dry matter production of the crop on the Ridges was significantly higher than of the Control and the Raised beds while the bulk density in the top 5cm was significantly lower. The variety Camm yielded the same on the Ridges and the Control with the Raised beds yielded the lowest because the productive area of the beds was adjusted for the presence of the furrows (20%). This was not done for the Control even though these plots, which were designated as buffer plots for the raised beds, did receive a drainage benefit from the furrows in terms of shedding excess soil moisture. These buffer plots were used for the Control because the designated Control plots were too wet to seed at the time the trial was sown. Wyalkatchem wheat yielded significantly less ($p = 0.006$) than Camm in all the treatments because for the latter, being a long season variety, the long wet 2005 season was advantageous

Concluding comments

Whilst the preliminary results are interesting more work needs to be done to establish the robustness of this system and several issues would need to be looked at.

- Tyne design is important. A new tyne is being developed that makes the furrow and sows seed in one pass and should bolt on to standard seeder units. Note, in this system only one tyne is required per two seed rows.
- The incorporation of herbicides needs to be addressed.
- The orientation relative to the slope needs investigation.
- How is stubble being handled? Is the engagement of soil with stubble could be an advantage?
- How would the yield in dry seasons be affected? Proper seed placement is important, even more so in dry years. Just dropping the seed on the ridge is not recommended.
- How sensitive is the system to wind erosion?

Some of these issues are currently under investigation at the MBRS and the Esperance Downs Research Station.

It is very possible that the WSF as a system is more appropriate for the sandy /gravely duplex soils while ridge seeding might be more appropriate for the heavier soil types such as the grey clays. Future research should identify these areas and applications.

Acknowledgements

The assistance of Rob Hetherington (DAWFA) in all aspects of experimentation is greatly acknowledged, as is the contribution of the staff of the MBRS. The collaboration of Russel and Margaret Thomson (Woodanilling), Michael and Marie White (North Stirling) is acknowledged.

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