Raised bed farming in WA, an application to saline land.

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INTRODUCTION

Significant areas of the Western Australian Wheat Belt experience elevated levels of soil salinity and are prone to waterlogging particularly in lower lying areas. The increase in soil salinity caused by rising ground water tables, has severely altered the farming options in those areas. Historically they produced good cereal yields but are now reduced to marginally yielding areas or are excluded from cropping altogether. They are now used exclusively for grazing with little scope for improved pastures except perhaps for the utilisation of saltbush.

Transient waterlogging has also been recognised as a factor severely limiting the potential yield in many years, depending on the annual rainfall received. For several years research into the application of raised beds to alleviate waterlogging has clearly shown that significant yield increases can be obtained with that farming system. The impact of raised beds on waterlogged and saline land has not been clear and has been the subject of a research project funded by the Department of Agriculture of Western Australia (DAWA), the Grains Research of Development Corporation (GRDC) and the CRC for Plant Based Management of Dryland Salinity.

Aspects associated with raised beds thought to be beneficial in the cultivation of saline land are:

- The ability of raised beds to leach salts from the root zone
- The increased soil cultivation limits the capillary rise in spring and reduces the re-salinisation of the root zone
- An increase in the runoff from the beds reduces the accession of the ground water, which will have a positive long-term effect on the water table.
- The ability of raised beds to increase the productivity from waterlogged land increases the evapotranspiration from the beds and reduce the salinisation of the root zone.

METHOD

Three large (about 60 ha) experimental areas located in the South Western part of WA and were selected on the basis of the range of salinities, the susceptibility to waterlogging, the willingness of the landholder to collaborate and their representation of significant portions of the landscape. The initial salinity across the areas was established through an EM38 survey and the topography assessed with a Beeline® DGPS system. Based on this information the experimental layout was determined, shallow surface drains and the treatments installed in 2002. The treatments consisted of a cropping and a pasture area with raised beds which are beds made following a deep soil cultivation and an annual soil loosening, no-till beds which are beds made without any prior soil cultivation or annual soil loosening and a control. The choice of crop and pasture composition varied from site to site and was determined by the growers.

OBSERVATIONS

Changes in the soil salinity of the top 15 cm was determined on fixed points across the experimental area through repeated soil sampling. After 2 years the depth was increase to 60 cm at a smaller number of points but with more reps per point. Piezometers to measure the fluctuation of the ground water were installed in several plots and monitored regularly. Changes in the salinity across the area were determined from EM38 surveys done during the winter and the summer. Biomass estimates of the pasture and the crop were derived from digital multi-spectral images, obtained in September. “Ground-truthing” of the images occurred at the same time by actually cutting pasture and crop samples. The reflectance of the 4 bandwidths (Red, Blue, Green and Near-Infra-Red) gave different correlations with the biomass. The image producing the best correlation was used to estimate the spatial distribution of the biomass. Pasture composition was determined during the EM38 surveys using a series (7) of potentiometers each representing a species including bare ground. During the survey done using an ATV the position of the potentiometer was changed to reflect the composition, i.e. a pure rye grass (RG) stand would result in the RG potentiometer fully open and the rest closed. The same logger logging the EM38 logged the position of the potentiometers. At harvest time the spatial distribution of the yield was recorded with a yield monitor and a DGPS. Gross plot yields were obtained by weighing the header empty and full using large roll-on/roll-off weighing platforms.

RESULTS AND DISCUSSION

The results presented are limited to one site (Woodanilling) only because the sites did not vary greatly in the way they performed and the type of relevant issues.

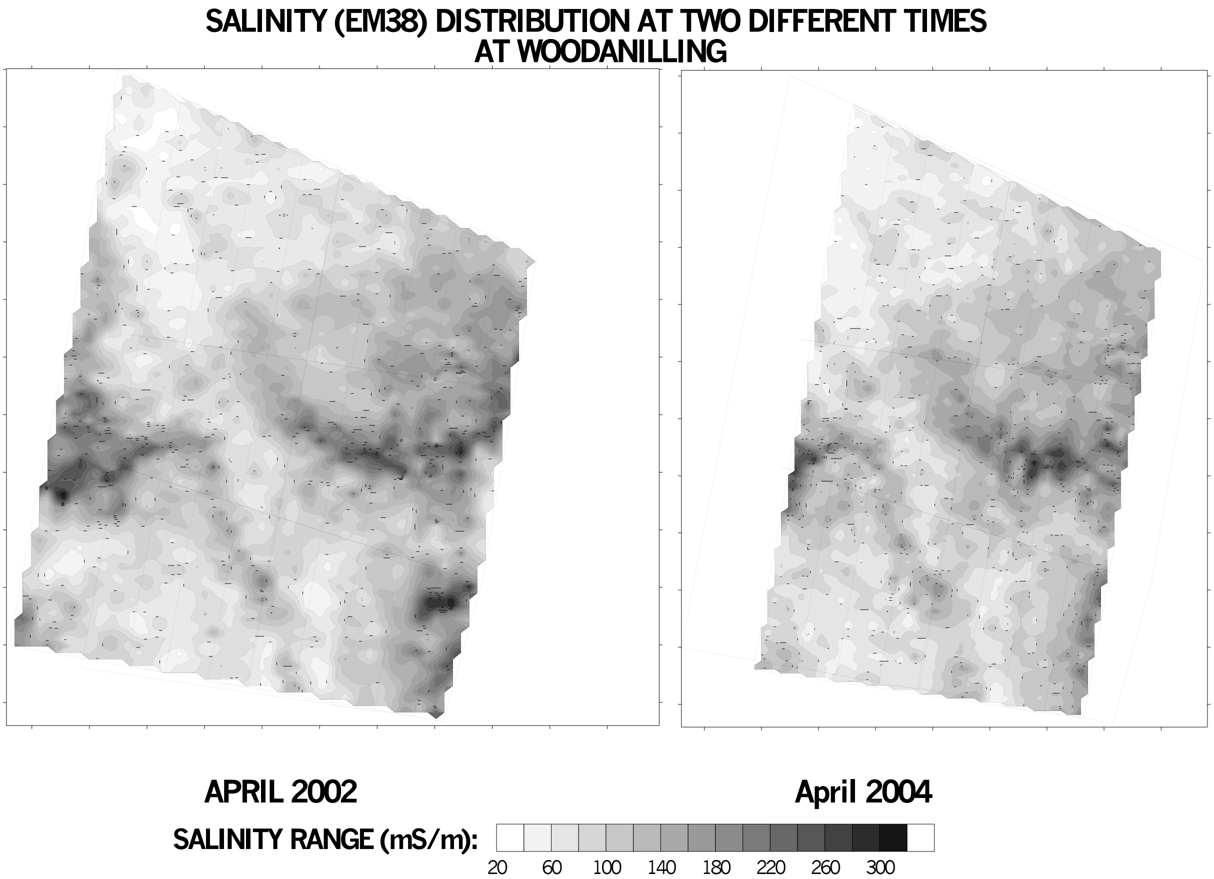


Figure 1 Salinity distribution (EM38) at Woodanilling in April 2002 and 2004

A salinity level of >300 mS/m severely affects crop/pasture growth. From the figure it is clear that several areas are affected but some of the ‘hot-spots’ had reduced in size by April 2004.

The soil salinity and moisture with depth at two locations is portrayed in Figure 2.

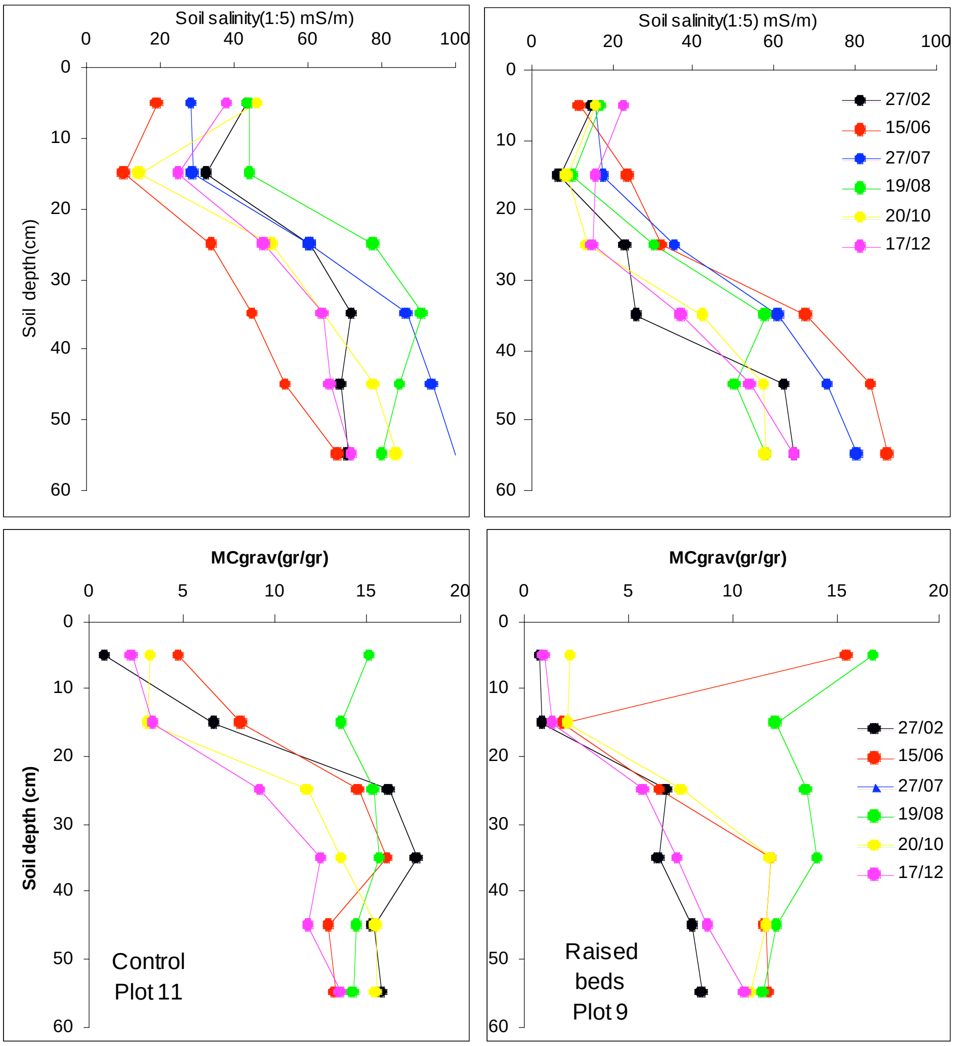


Figure 2 Salinity (top) and soil moisture profiles (bottom) in Plot 11 (Control) and Plot 9 (Raised beds) *Moisture content results from 27/07 were lost.*

It was generally found that the bulk soil salinity levels increased during the winter months and decreased during the summer months, particularly at the lower depths. It was expected that the salinity levels would decrease during the winter and increase during the summer, however in many of these areas, the influence of shallow ground water is significant. There was little difference other than some sampling variation in the way the control and the raised beds affected the movement of salt.

In Figure 3 some trends in the ground water table are shown.

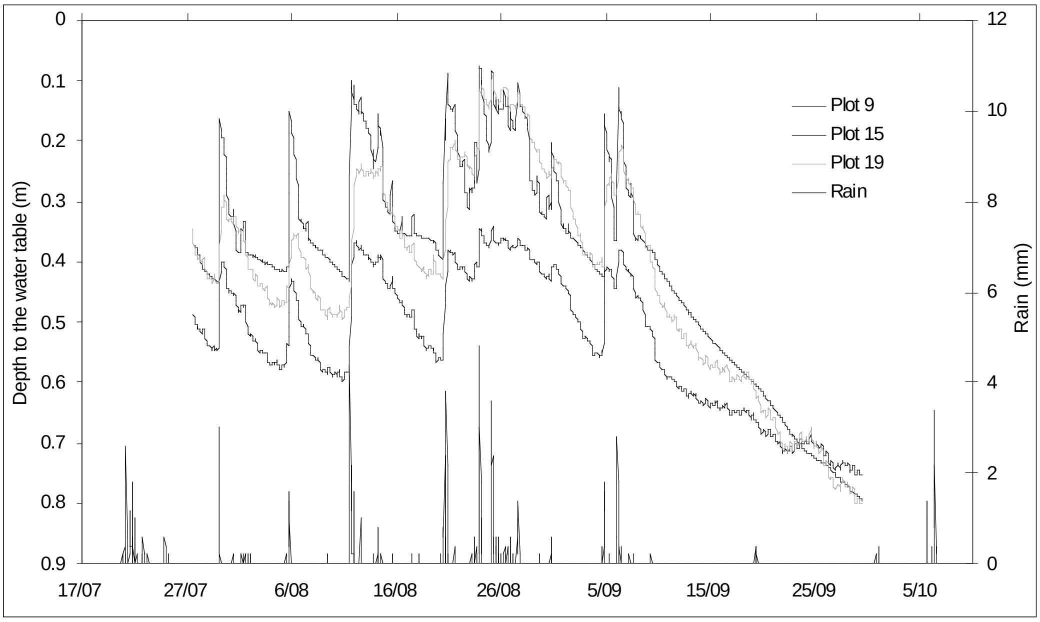


Figure 3. Movement of ground water in relation to rain fall in 2004 (a dry year).

From the figure it is clear that the water table responds very quickly to any amount of rain. The system reacts like a one-dimensional system with some water draining away over time and through evapotranspiration later in the season with no quantifiable difference between the raised beds and the control.

The quality of the ground water varies but is usually close to seawater quality (i.e. 5500 mS/m). When the water table rises and introduces saline water in the subsoil, the soil salinity increases correspondingly. At the same time the rain will leach salt away and down into the profile diluting the soil solution. The result is a rather complex movement of salt, particularly during the winter months. During the summer months, with at least the rainfall absent, the movement of salt becomes simpler even though a falling water table and the throttling effect of the dry topsoil add to the complexity of the process.

The barley yield of 2004 is presented in the following table.

Table 1 Plot barley grain yields in 2004 from the Woodanilling site.

Rep	No-Till beds (T/ha)	Raised beds (T/ha)	Control (T/ha)
1	3.38	3.15*	
2	2.64	2.05	1.53
3	0.98	0.71	0.97
4	2.11		0.79
Mean	2.28	1.97	1.09

There was a large difference between the productivity of the beds and the control. Even though dry conditions were experienced during the latter part of the growing season, during the winter months waterlogging did occur on many occasions severely affecting the productivity of the control plots. However poor soil fertility and weed control on certain areas affected the yield from the beds.

The yield was greatly affected by waterlogging as well as salinity which is presented in Figure 4

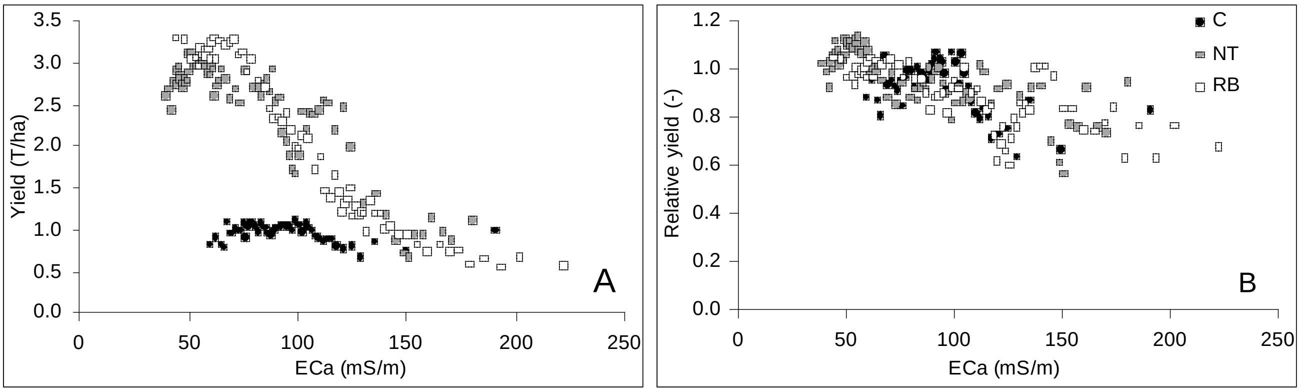


Figure 4 Yield as a function of salinity for the control, raised beds and the no-till beds (A) and the relative yield (B).

The yield in the beds remained constant until a level of about 80 mS/m after which the yield declines rapidly with only a slight hump in the NT treatment at about 120 mS/m. Because the waterlogging affected the control severely the yield results have also been presented in terms of relative yield, i.e. the ratio of the yield in each point in a plot and the yield in that plot at the lowest level of salinity (Fig. 4B). No obvious difference is present between the treatments in the salinity effect on relative yield (Fig. 4B). What appears to be a salinity effect in Figure 4A is somewhat confounded by other factors as presented in the next section.

There was a great difference between the yield in the various plots for a given salinity as presented in Figure 5.

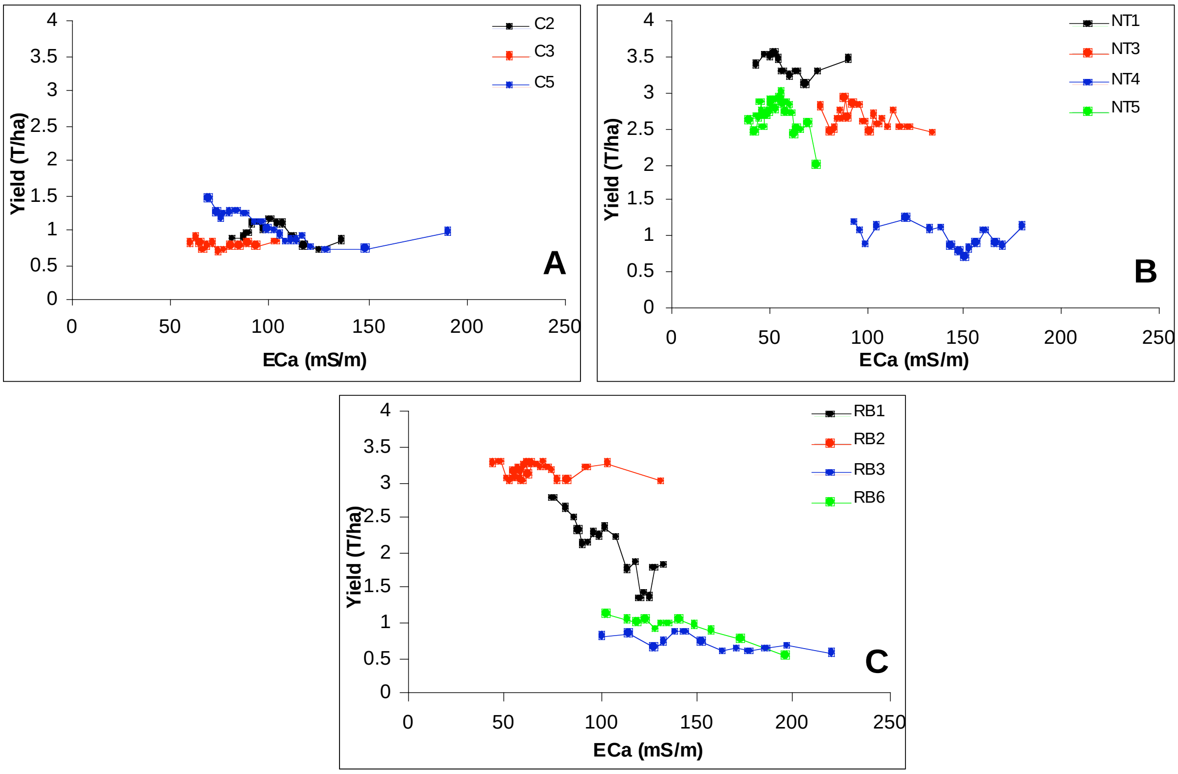


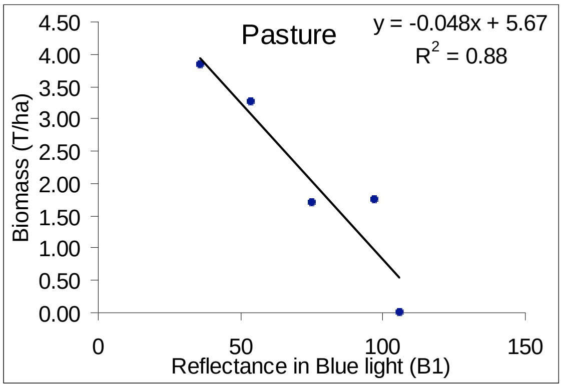
Figure 5. Yield as a function of salinity separated in the plots for the control (A), the no-till beds (B) and the raised beds (C).

Little difference was found between the plots in the control (Fig. 5a). All plots were affected by waterlogging and weeds to a point that salinity did not affect the productivity. In the no-till beds NT1 was the most productive plot, followed by NT5 and NT3. Plot NT1 has the largest depth to the ground water, the best nutrition, the least exposed to waterlogging and very few weeds. The salinity levels in NT3 go up 140 mS/m but the productivity is only marginally affected by the salinity. This indicates the yield potential even under elevated salinity levels. The productivity of the raised beds varies greatly. Good yields were achieved in RB2 adjacent to NT1, well drained, a good fertiliser history, few weeds despite some moderate salinities i.e. up to 130 mS/m, again illustrating the yield potential for such salinities. RB1 is poorly drained despite the presence of beds, a poor fertiliser history and not very productive. RB3 is also poorly drained as well as poor weed control, fertiliser history and very high salinities resulting in an overall poor productivity. RB6 is very well drained but has high levels of salinity, a poor fertiliser history and has a big weed problem which upsets the yield potential. Using 120 mS/m as an indicator the yield ranged from 3 to 0.9 t/ha for RB2 and RB3 respectively.

Assuming that at 120 mS/m the yield is not yet affected the potential to improve yields by better drainage, fertiliser application and weed management is considerable (i.e. 2 t/ha). From this approach it is clear that large gains in the yield here at Woodanilling can be expected to be made when salinity is the only limiting factor and when weed control, fertiliser and surface water management are improved.

Pasture Productivity and Composition

The pasture productivity was derived from the reflectance of blue light using the equation presented in Figure 6.



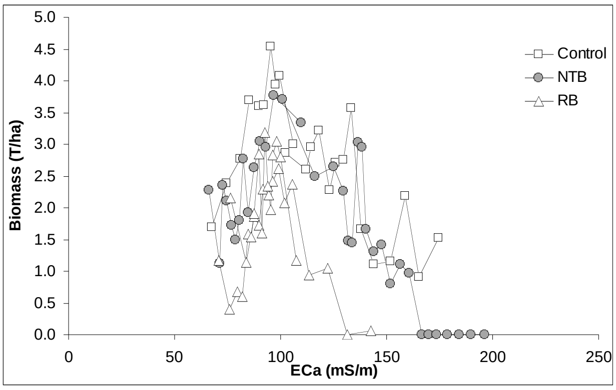


Figure 6 Blue light reflectance (left) and the pasture productivity at the end of September (Right).

There was no strong correlation between the salinity and the productivity with a peak around 100 mS/m. The raised beds did not do well due to the presence of bare furrows, following the soil loosening and furrow cleaning process.

The pasture composition was expressed as a presence of rye grass and cape weed, the first a sign of a healthy pasture and the latter evidence of a poorer pasture. The composition was determined in September 2003 and again in July 2005 and is presented in Figure 7.

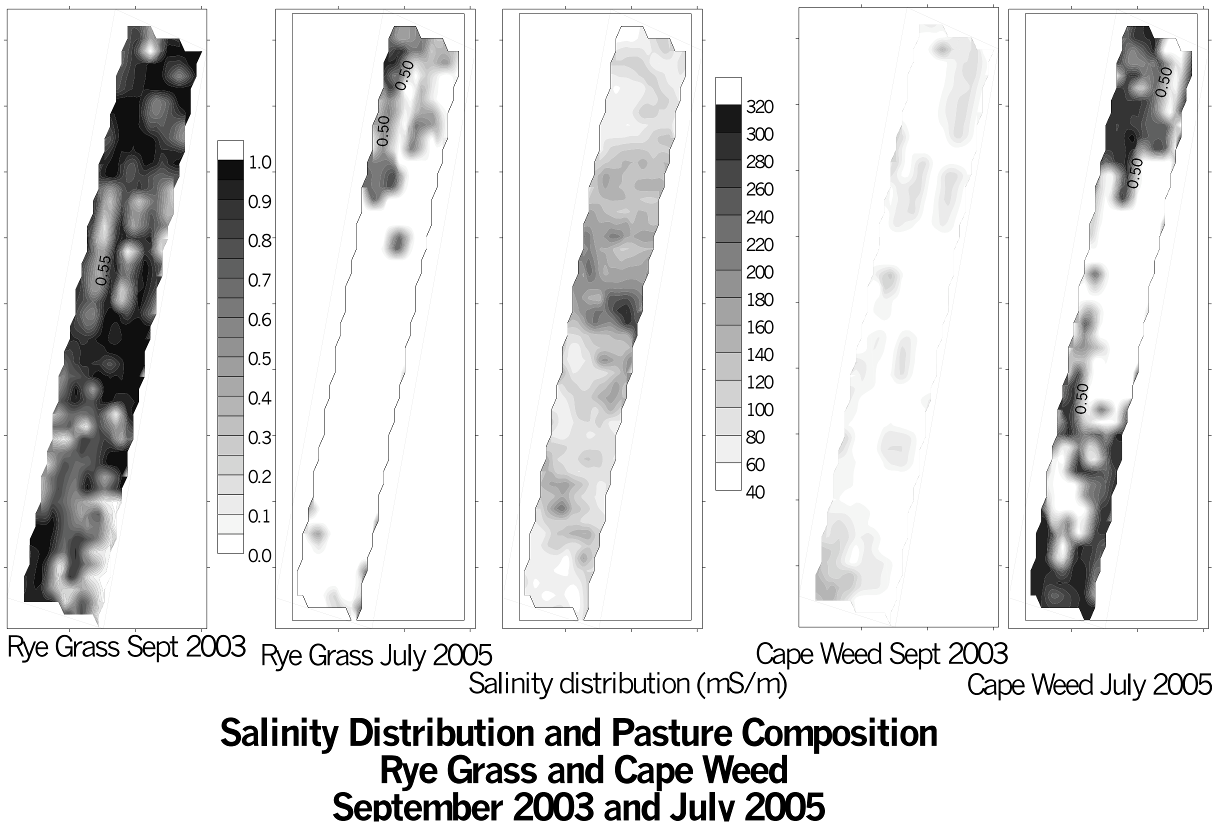


Figure 7. Salinity distribution and pasture composition changes over two years at Woodanilling. 1 = Solid stand and 0 = nothing present.

A severe degradation of the pasture occurred over the two years the surveys were conducted. In September 2003 the pasture had not yet been grazed and the rye grass grew prolifically. This almost entirely disappeared after two years of intermittent grazing while the cape weed showed the reverse. While the rye grass seems to survive in the areas with a low salinity there was no obvious treatment effect. The raised beds while providing very good surface drainage did not halt the decline of the pasture. Salinity had an effect on the composition as did soil type. At times waterlogging did seem to have a positive effect on the pasture with pockets of clover established in the wettest areas.

CONCLUSIONS

The introduction of raised beds to waterlogged saline increased the farming systems options available for this type of landscape. The alleviation of waterlogging greatly improved the yield, but pockets of high salinity limited the yield in those areas. Other factors however such as soil fertility and weed burden limited the actual yield also. The dynamics of the salt balance is governed by proximity of a sometimes very saline ground water table, which in conjunction with the ‘right’-soil type expresses itself as “hot-spots” of salinity. Increasing the depth to the ground water would reduce the threat to salinity but is, at the same time, difficult to achieve in this flat landscape and the one-dimensional nature of the water movement during the winter months. The implementation of raised beds did not improve the pasture growth neither improved nor maintained the pasture composition. If surface drainage is warranted in pasture production other means to improve intensive surface drainage need to be considered.

ACKNOWLEDGEMENT

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