PRODUCTION PERFORMANCE OF PERMANENT RAISED BEDS IN WIDELY DIFFERING SOIL & CLIMATIC REGIMES IN WA.

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INTRODUCTION

Waterlogging has long been recognized as a major constraint to crop growth. Waterlogging in the South Western region of Western Australia (WA) is predominantly the result of perched water tables in duplex soils, caused by rainfall in excess to evapotranspiration limited percolation through the subsoil and lateral drainage. Surface drains have often been recommended to alleviate water logging however with little success due to poor lateral water movement. The concept of raised beds has been well established in irrigated agriculture (Tisdall and Hodgson, 1990). However, the application of raised beds to dryland agricultural area, notably waterlogged duplex soils has not been investigated. Raised beds provide short drainage pathways and reasonable hydraulic gradients. They improve lateral water movement, resulting in less water logging in the root environment, and increase in evapotranspiration and subsequent biomass accumulation. This paper describes the first-year crop production results of raised beds on waterlogged duplex soils in the South West of WA. The effect of raised beds on the hydrology of duplex soils has been described else where (Bakker and Hamilton, 1998).

MATERIALS AND METHODS

Four demonstration sites in Beverley (B), Woodanilling (W), MtBarker (MB) and Esperance (Esp) were installed in 1997, covering a range of soil types and climatic conditions across the South West corner of WA. The soil types at these sites are respectively, a shallow sandy clay loam over clay, a sandy loam over clay, a sand and gravel over clay and, again, a sand and gravel over clay. Two replicated treatments were installed at the sites: the conventional or district practice, being the control, and raised beds. The district practice consisted of a shallow cultivation prior to seeding while the raised bed treatment received a deep cultivation, the application of gypsum on those sites where dispersible subsoil was present (B and W) and the formation of the beds.

The raised beds were installed using a furrower/bedformer, an implement commonly used in irrigated agriculture. Curved blades mounted on ripper shanks, spaced at 1.8 m, formed furrows while horizontal blades mounted behind the shanks ensured the formation of a level bed. Three complete beds and two half beds are formed with each pass of the implement. The seeder was a conventional double disc seeder unit mounted on three-point linkage. All sites were sown to oats which has a vigorous root mass and should aid the establishment of a stable soil structure in the beds.

In addition to the demonstration sites, a research site has been established at Cranbrook where more detailed observations are carried out, such as runoff monitoring, soil moisture in the profile, degrees of waterlogging and climatic conditions. Prior to the establishment of the crop in 1998, hydraulic conductivity measurements were made on most sites using disc permeameters. In 1998 at CB the treatments, control and raised beds, were split into 'with' and 'without' stubble grazing.

On all sites crop growth and yield measurements were carried out. Growth measurements (i.e. dry matter accumulation) were obtained twice (September and October) during the season while the final yield was determined at harvest time using a plot harvester.

For the Cranbrook site only, waterlogging has been assessed manually using dip wells. The average depth to the water table has been taken from all observations.

For all the sites rainfall records during the growing season were obtained from automatic weather stations or manually recorded rainfall gauges on grower properties.

RESULTS

Dry matter content and the yield of the control and the raised beds are presented in Table 1 and Table 2, respectively.

Table 1. Dry matter content at two different times during the growing season. Standard deviation between brackets.

	Dry Matter (t/ha) Sept		Dry Matter Oct	
	Control	Raised Beds	Control	Raised Beds
Beverley	4.75 (0.25)	6.90 (1.26)b	6.17 (0.85)	8.21 (1.30)c
Woodanilling	4.30 (1.15)	5.86 (0.56)c	8.54 (0.74)	11.75 (1.08)b
Cranbrook	2.52 (0.76)	4.60 (0.77)a	6.99 (1.93)	10.54 (1.81)b
Mount Barker	4.72 (1.10)	4.55 (0.37)	7.92 (0.60)	8.29 (0.04)
Esperance	4.34 (1.01)	6.01 (0.36)	5.39 (1.91)	8.91 (0.10)

a = stat. different at P = 0.001, b = stat different at P = 0.05 and c = stat. different at P = 0.1. No letter indicates not statistically different at those levels.

Table 2. Yield. Standard deviation between brackets

	Yield (t/ha)	
	Control	Raised Beds
Beverley	1.14 (0.27)	1.44 (0.28)
Woodanilling	1.70 (0.38)	2.50 (0.20)b
Cranbrook	2.26 (0.54)	2.76 (0.42)b
Mount Barker	2.59 (0.48)	2.00 (0.40)
Esperance	1.78 (0.55)	2.58 (0.24)

a = stat. different at P = 0.001, b = stat different at P = 0.05 and c = stat. different at P = 0.1. No letter indicates not statistically different at those levels.

Good correlations were found between the average depth to the perched water table and the dry matter content (Fig. 1a) as well as the yield (Fig. 1b).

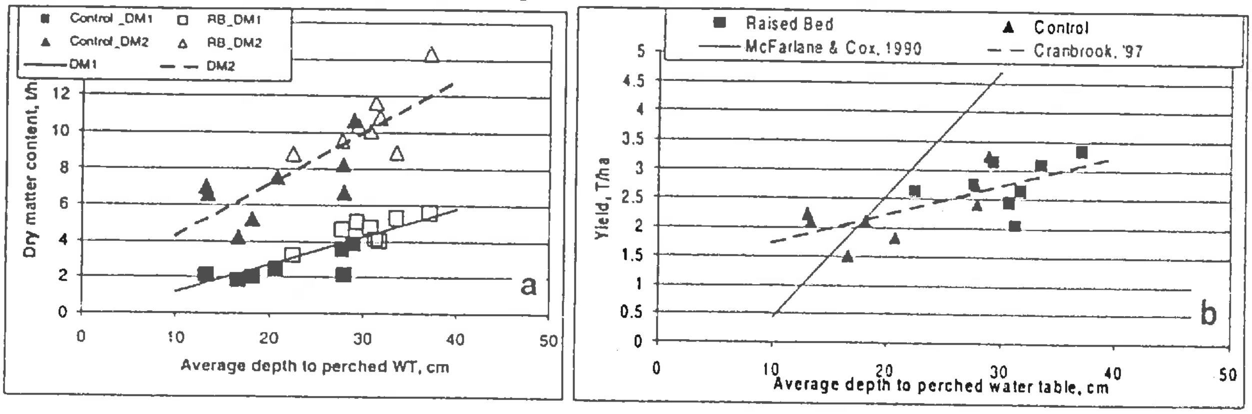

Figure 1. Relationship between average depth to perched water table and dry matter (a) and yield (b).

The rainfall summary as well as decile ranking which is the position of the monthly rainfall in a distribution of historical rainfall arranged in order of magnitude for the five sites is presented in Table 3. The decile ranking is a good indication how the actual rainfall compares to the long term average rainfall.

Table 3. Actual rainfall (mm) and decile ranking, between brackets, at the demonstration and the research sites over the growing season..

	May	June	July	August	September	October	November
Beverley	28 (2)	35 (1)	42 (2)	66 (7)	37 (5)	21 (4)	5 (3)
Woodanilling	71 (7)	76 (4)	39 (2)	65 (6)	28 (3)	14 (2)	12 (2)
Cranbrook	70 (7)	57 (4)	75 (6)	74 (7)	51 (5)	15 (1)	16 (4)
Mount Barker	40 (3)	59 (2)	71 (3)	76 (4)	76 (4)	23 (2)	20 (2)
Esperance	96 (7)	54 (3)	51 (2)	118 (8)	66 (6)	4 (1)	30 (4)

DISCUSSION AND CONCLUSION

The effect of waterlogging on crop dry matter production and yield is well documented following laboratory studies (see Barrett-Lennard, (1986) for references, or lysimeters studies (Cannell et al. 1980) but is not easily established on a field scale without going to the extent of creating artificially ponded areas as done by Barrett-Lennard et al.(1985) or selecting small quadrats (McFarlane and Cox, 1990). There is a good correlation between the average depth to the perched water table and the dry matter and the yield. The relationship derived by McFarlane and Cox (1990) using quadrats, has a much larger slope and provides an overestimation of the effect of waterlogging. The use of raised beds effectively eliminates waterlogging (Bakker and Hamilton, 1998), therefore the development of the waterlogging-dry matter/yield correlations using raised beds is a powerful tool to establish the cost of waterlogging to the industry in conjunction with waterlogging simulations.

From Table 3 it can be seen that all sites experienced less than average rainfall (Decile <5) at the time of bed mounding and seeding which was the middle of June, 1997. Cranbrook experienced average conditions in July while the other sites received less than average rainfall. Esperances received much more than average rainfall in August with the remainder of the sites apart from Mount Barker receiving more than average rainfall. All sites, except Woodanilling, received average rainfall in September and all sites experienced a drier than average drying-off season. Despite the sometimes dry conditions and therefore the lack of waterlogged conditions at the beginning of the growing season (documented for Cranbrook but not in the other sites), the raised beds produced more dry matter and yielded higher, except in Mount Barker. The formation of the raised beds is accompanied with a lot of soil disturbance, the formation of macro porosity, and the addition of soil ameliorants (i.e. gypsum). In that respect the hydrological advantance of the raised beds in alleviating waterlogged conditions is also associated with a tillage effect which explains the treatment differences even under drier conditions such as in Beverley and Woodanilling. Eventhough for the Cranbrook site, the similarities between slopes of response of the control and the raised beds to waterlogging, suggest that for the Cranbrook soil waterlogging is the main contributing factor to the variation in dry matter or yield.

There is anecdotal evidence that substantial soil disturbance associated with a dry finish to the season results in a reduction in yield. This might have to be considered in the assessment of the benefits of raised beds in soil moisture limiting conditions. The progression in treatment differences during the growing season in relation to rainfall (i.e. decile ranking) is presented in Table 4

Table 4. Changes in treatment differences, defined as: ((RB-Control)/RB*100%) for the five sites on three different occasions. The third decile ranking applies to November while most crops were harvested in December.

Location	Period	% difference	Decile ranking
Beverley	Sept	45.3	5
	Oct	33.1	4
	Yield	26.3	3(N)
Woodanilling	Sept	36.3	3
	Oct	37.6	2
	Yield	47.1	2(N)
Cranbrook	Sept	82.5	5
	Oct	50.8	1
	Yield	22.1	4(N)
Mount Barker	Sept	-3.6	4
	Oct	4.7	2
	Yield	-22.8	2(N)
Esperance	Sept	38.5	6
	Oct	65.3	1
	Yield	44.9	4(N)

In Beverley there seem to be a correlation between the constantly drier season and reduced differences, but this was not repeated in Woodanilling. The differences in Cranbrook were dramatically reduced following an average September and a very dry October, whereas the dry matter production in Esperance was boosted following the wetter than average September but the very dry October. The yield figures at Mount Barker did not follow the trend seen anywhere else. Even though the season in MountBarker has been drier than average, the dry finish seem to have had a larger effect on the raised beds than on the control.

From the changes in dry matter and yield differences between the control and the raised beds across all five sites there is no consistent pattern that suggest that raised beds are more affected by limited soil moisture availability later in the season than the control. However continuing research efforts and mor detailed observations will address this aspect of the raised beds in the 1998 growing season.

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