Successful high rainfall cropping in southern Australia using raised beds

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Abstract

An experiment was established at Hamilton in south-western Victoria in 2000 and 2001 to assess the effectiveness of raised beds for improving crop growth and yields. Although wheat often produced higher yields per m^2 on the beds, once yield was calculated on a per hectare basis, yields were often either lower or not significantly different to those from flat conventional sowing due to a 25-30% loss of production area from the furrows. Crops appeared more vigorous on the raised bed treatments and provided greater competition for weeds.

Keywords

Waterlogging

Introduction

The effects of waterlogging on crop growth and yields have long been recognised. Reports of the area affected by waterlogging have been up to 12% of agricultural soils in the USA (4) and 40% of the cereal growing area in the UK (4) with yield losses of 100% reported in farmers paddocks in Western Australia (2). Waterlogging is seen as a major factor preventing successful cropping in south-western Victoria in some instances also causing up to 100% loss of yield. Wheat yields in the region average 3.4 t/ha (3) despite predictions in the 1980's that due to the long growing season and fertile soils, yields should consistently reach 7 t/ha (1). The recent introduction of raised bed technology has provided farmers with a means to minimise or eliminate waterlogging, thus making cropping in the area profitable. This experiment compared the growth and yields of wheat grown on raised beds and conventional flat land.

Methods

In 2000 and 2001 at Hamilton in south-western Victoria, comparisons were made between two varieties of wheat grown on raised beds and on flat land at two sowing times and three densities.

The soil type is a fine sandy clay loam, pH ($CaCl_2$) 4.7, organic matter 9.5% w/w, total carbon (Leco) 5.0% w/w, total nitrogen (Leco) 0.41% w/w, phosphorus (Olsen) 14 mg/kg, potassium (Skene) 190 mg/kg and sulphur (CPC by ICP) 9 mg/kg. In January 2000, the area was deep ripped to 20 cm, cross ripped to 25 cm and then line harrowed. Contour maps of the trial area, at 25m intervals were developed using Global Positioning Satellite (GPS) prior to the formation of raised beds. Raised beds, 1.7m wide (furrow to furrow) ? approximately 20 cm high, were formed and reformed on three occasions between February and April in 2000 on the drainage treatments. On the final pass, a pre-emergent herbicide (pendimethalin) was applied to control grass weeds and glyphosate was applied as a knockdown on both the bed and flat treatments. Crops were sown in May and July using a plot cone seeder and seed was covered with light harrows. Plots were 108.8 m^2 (6.8 m wide or four beds x 16 m long). Broadleaf weeds were chemically controlled in July using clopyralid (for the May sowing date) and toadrush (*Juncus bufonius*) was chemically controlled using terbutryn + MCPA in September in 2000 (for May and July sowing date) and immediately after sowing (s-metolachlor) in 2001. Pests (insects and slugs) were chemically controlled as required.

Measurements

At crop maturity (January), total above ground material was harvested using hand shears. Three cuts were taken per plot using quadrats 170 cm x 59 cm to give a total area harvested per plot of 3 m^2. Quadrats were placed across the beds so that the area harvested included the furrows and yields could be calculated on a per hectare basis. Grain was removed from the heads using an electric seed thresher (Kimseed Machinery, Footscray, NSW) and weighed to determine yield. In 2001, weed biomass was determined two weeks before the crop was harvested by taking 3 x 0.1 m^2 quadrats per plot and drying samples to a constant weight.

Statistical design

The experimental design was a row-column layout, split for subplots. The experiment was replicated three times and was configured in six long columns with each column assigned either a flat or a raised bed treatment. A second blocking factor was crossed with the columns to produce three strips (3 x 6 row-column layout). This factor was included to account for variation encountered due to the slope of the paddock. Time-of-sowing treatments (three levels ,May, July and spring) were allocated to the 3 x 6 row-column design to ensure that each column was allocated the three levels of time-of-sowing once, and each row (or strip) was allocated three levels of time-of sowing twice. The 3 x 6 row-column plots were further split into six subplots for the investigation of two varieties by three densities (normal, half and double district sowing rates). This paper does not report on the effects of the third sowing time (spring), sowing density or cultivar. Data was analysed using REML (Genstat 5.42). The 5% significance level was used to test all yield differences.

Results

The 2000 and 2001 seasons were contrasting for rainfall with 2000 being drier than average and 2001 having higher rainfall than the long term average (Figure 1).

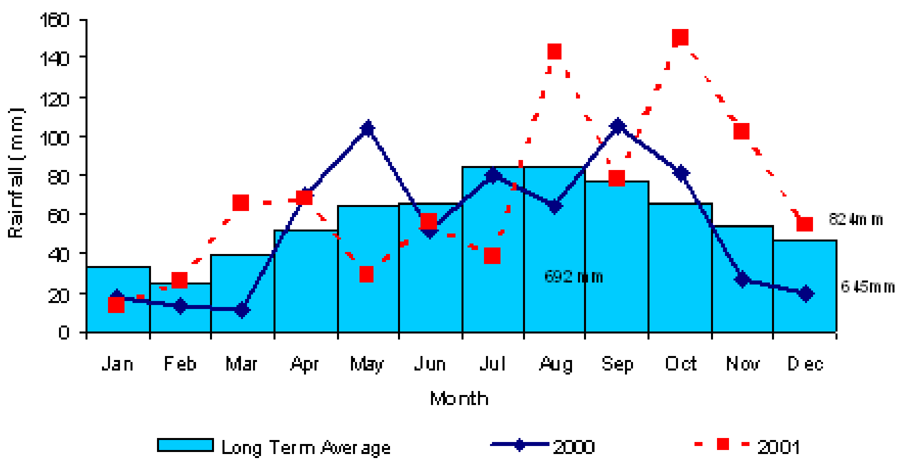

Figure 1: Monthly and annual rainfall for 2000 (__), 2001 (_ _ _) and the long-term average (shaded bars) at Hamilton in south-western Victoria.

Raised beds had a greater impact on crop yields in the wetter year. Yields (g/m^2) were higher on the raised beds for May-sown crops in both years. There was no difference in grain yield (g/m^2) for the July sown crops in both 2000 and 2001 (Figure 2).

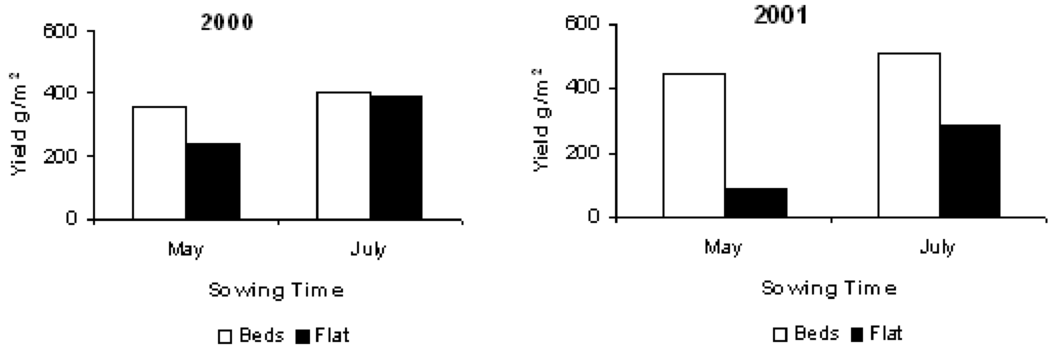

Figure 2: Yields (g/m^2) of wheat (combined means of cultivars Kellalac and Tennant) sown in May and July, on raised beds or conventionally sown on flat land for 2000 (sed = 30.31) and 2001 (sed = 110.7)

Although the crops appeared to grow more vigorously on the raised bed treatments, this often did not translate to significantly higher yields than crops sown on the flat when calculated on a per hectare basis, as the furrows can remove up to 30% of the production area. There were no significant differences ($P<0.05$) in yields between wheat sown either on raised beds or flat land in May 2000 or in July 2001. For wheat sown in May 2001, crops sown on flat land produced lower yields than all other treatments, most likely due to a combination of waterlogging and disease. In 2000, yields of wheat sown in July on flat land were higher than those sown either in July on raised beds or in May on raised beds and flat land (Figure 3). Higher yields obtained from crops sown in July on the flat were most likely due to the lower rainfall in 2000, which may have caused moisture stress to crops on the beds during the grain filling period.

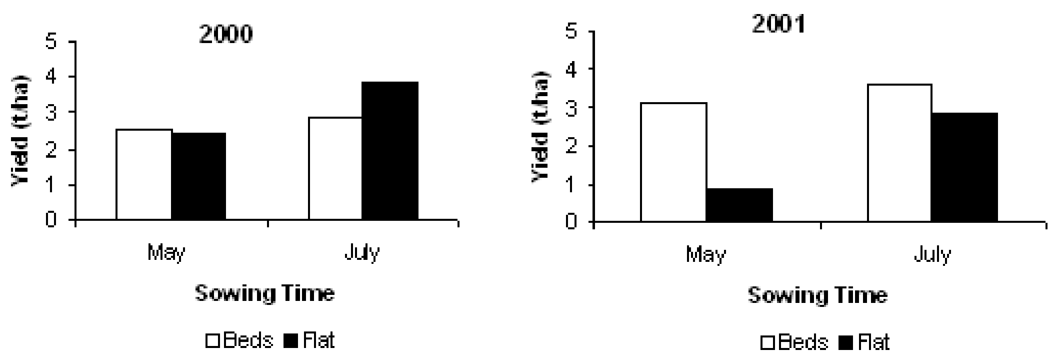

Figure 3: Yields (t/ha) of wheat (combined means of cultivars Kellalac and Tennant) sown in May and July, on raised beds and conventional sowing on flat land for 2000 (sed = 0.25) and 2001 (sed=0.95), taking into consideration production area lost to the furrows.

Weed biomass was higher in the crops sown on flat land than in those sown on the beds. By reducing waterlogging on raised beds, crops are less stressed and therefore less likely to be susceptible to weed infestations. Later sown crops also had fewer weeds (Figure 4). This has important management implications for farmers as, during winter and spring, wet soils and poor weather conditions often make herbicide application impossible.

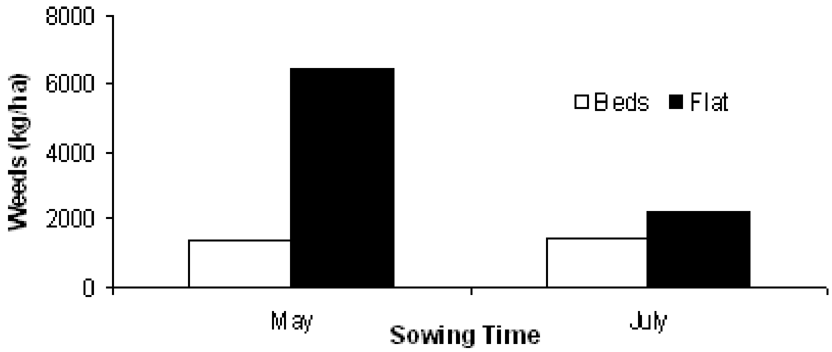

Figure 4: Weed biomass (kg/ha) in crops sown in May and July on raised beds and on conventional flat land in 2001 (sed = 1764).

Conclusion

In the wet year, crops sown on raised beds appeared more vigorous and often produced higher yields than crops sown on conventional flat land. However, the value of beds will only be realised in wet conditions where waterlogging is likely to cause yield losses in excess of 25-30% due to the loss of production area from the furrows. An additional advantage of raised beds may be reduced reliance on chemicals due to better crop competitiveness, which will have environmental, economic, and management benefits.

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