Improving canola yields in the high rainfall zone of southern Australia

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ABSTRACT
The effect of raised bed drainage on canola growth and yield was determined in 2000 and 2001 at Hamilton in south-west Victoria. Mystic and Charlton were sown at three sowing times at three sowing rates on raised beds and conventional flat land. Significant effects were detected at the higher strata (drainage or drainage by time of sowing). In 2000, crops sown on raised beds had significantly higher yields (3 fold increase) and harvest indices (1.5 fold increase) than those sown on the flat. In 2001 there was a drainage by time of sowing interaction for yield, harvest index and blackleg rating. In this year, drainage significantly increased yield only in the July planting (5 fold increase). Harvest index was significantly reduced in the May sowing. Blackleg rating was significantly improved for the later sown crops (July). In both years there was also a significant drainage by sowing time interaction for plant height and weed infestation with crops sown later (July compared to May) on raised beds growing taller and being less infested by weeds. These results suggest that, in the high rainfall zone, raised beds could provide an opportunity to widen the sowing window, reduce downside variability of yields and offer options for weed and disease control through later sowing times.

INTRODUCTION
Winter waterlogging is a major cause of reduced crop yields in the high rainfall zone (HRZ) of southwest Victoria. Waterlogging in this region is the result of hardpans or dense subsoils that impede water movement through the soil profile. The presence of perched water tables during winter when rainfall is high and evaporation is low culminates in poor moisture movement and restricted root growth through the subsoil. In Victoria 3.75 million hectares have been assessed as having surface or subsurface waterlogging problems (MacEwan et al. 1992). The introduction of drainage through raised beds has seen a significant increase in area of cropping in south-west Victoria from 10,000 ha in 1997 to over 450,000 ha in 2005 (Bluett pers comm.).

Few studies have been conducted to determine the effects that raised beds have on the growth and yield of canola. We conducted an experiment to identify the differences in canola growth and yields when sown on raised beds compared to crops sown on conventional flat land.

MATERIAL AND METHODS
The experiment was conducted at the Department of Primary Industries, Hamilton in southwestern Victoria, Australia (37°49’S, 142°04’E). The average annual rainfall for the area is 692 mm/annum.

The soil type is a fine sandy clay loam, pH (CaCl₂) 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 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) data prior to the formation of raised beds. Raised beds, 1.7m wide (furrow to furrow) were formed and reformed on three occasions between February and April in 2000 on the drainage treatments for both the 2000 and 2001 sowings. 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.

Plots were 108.8 m² in size (6.8 m or four beds wide x 16 m long). Crops were sown using a plot cone seeder and seed was covered with light harrows. Two canola (Brassica napus)
cultivars, Charlton and Mystic, were sown on raised beds (not including furrows) and conventional flat land at two sowing times (May 23 and July 5 in 2000 and May 22 and July 5 in 2001) at three sowing rates (2, 5 and 10 kg/ha).

Broadleaf weeds were chemically controlled in July using clopyralid (for the May sowing date) and toad rush (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.

At crop maturity (December), 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. Seeds were removed from the pods using an electric seed thresher (Kimseed Machinery, Footscray, NSW) and weighed to determine yield. Weed biomass was determined two weeks prior to crop harvest by taking 3 x 0.1 m$^2$ quadrats per plot and drying samples to a constant weight. Visual assessments were conducted to determine proportion of major weed species present.

An assessment of blackleg infection was made in 2001. Ten plants were randomly selected per plot between the end of flowering and windrowing. Plants were cut at ground level and the percent of discoloration at the cross section was recorded. Statistical analysis was performed on the average value of the ten plants. The average height of 5 plants randomly selected per plot at harvest was used to assess plant height.

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 (drainage 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). The 5% significance level was used to test differences.

**RESULTS**

For this paper we only focus on the drainage and time of sowing effects. There were inconsistent effects of variety and density over the two years but predominantly there was no interaction with drainage and time of sowing except for in 2000 where there was a significant variety by drainage effect for yield. In this instance, the magnitude of yield difference between beds and flat was greater for Mystic than Charlton but the overall difference between beds and flats was still large.

Annual rainfall for 2000 was 50 mm below the long term average (LTA) (645 mm compared to 692 mm) although growing season rainfall (May – December) was only 8 mm less. In 2001, the annual rainfall was considerably higher (824 mm) than the LTA with the growing season rainfall approximately 90 mm higher. Most of the additional rain in 2001 fell over spring (Figure 1).
Figure 1. Monthly (a) and cumulative (b) rainfall for 2000 (solid line), 2001 (dotted line) and Long Term Average (bars) at Hamilton Victoria.

In 2000, crops sown on raised beds yielded significantly higher than those sown on conventional flat land (2.46 t/ha compared with 0.79 t/ha). In 2001, the effects of drainage were more apparent with the later sown crops with the differences in yields between the drained and undrained treatment being significant in July only (Table 1).

In 2000, crops grown on raised beds had a higher harvest index than those grown on the flat (0.36 compared to 0.24). Conversely in 2001, crops sown on beds in May had a lower harvest index (0.18) than those sown on the flat (0.26) with no significant differences in harvest index for crops sown in July (Table 1).

Plants generally grew taller on the beds, with the differences becoming more obvious for July sown crops. A drainage by sowing time interaction occurred with respect to weed biomass with biomass significantly lower for crops sown in July on raised beds. Similarly, blackleg infection was significantly lower for crops sown on the beds in July (Table 1).

Table 1. Drainage and drainage x time of sowing interactions across 2 varieties and 3 sowing rates for canola yield (t/ha), harvest index, plant height (cm), weed biomass (kg/ha) and blackleg score (%) in 2000 and 2001.

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¹No Blackleg assessment was conducted in 2000
²Where interactions are present, the l.s.d is the maximum value for all comparisons

Crops grown on the beds showed different patterns of dry matter accumulation than those grown on flat land (Figure 2). Crops grown on the flat appeared to accumulate less biomass particularly later in the season.
Figure 2. Biomass accumulation of canola sown across 2 varieties and 3 sowing rates in 2000 (a) and 2001 (b) for crops sown in May on raised beds and on the flat and for crops sown in July on raised beds and on the flat.

Discussion

Studies conducted to determine the effects waterlogging on oilseed yields have shown mixed results. Waterlogging has been reported to reduce dry matter and leaf development but not to have reduced seed yield (Heping et al. 2004; Cannell and Belford 1980). However, Gutierrez Boem et al. (1996) demonstrated that seed yield was affected by 3 or more days of waterlogging and the installation of mole drains to alleviate waterlogging in north east Victoria resulted in a 19% increase in canola yields compared to undrained plots (Johnston and Scott 1998). Junkai et al. (2002) also demonstrated an increase in rape yield with a decrease in the degree of waterlogging.

In this experiment, differences in canola growth and yield could be detected between crops sown on raised beds and on conventional flat land. There was a strong interaction between drainage and sowing time particularly in the wetter year (2001) where the benefits of raised beds were more apparent with the later sown crops. The extent of the damage caused by waterlogging is influenced by the crops stage of development when the waterlogging occurred (Gutierrez Boem et al. 1996). Crops sown on the flat in July would have been at an earlier stage of development and therefore more susceptible to the effects of waterlogging. By reducing the threat of waterlogging earlier in the crops development through the use of drainage such as raised beds, the sowing window for canola could increase in this region.

Crops grown on raised beds generally produced more biomass, grew taller and appeared less susceptible to disease and weed infestation. The effects of waterlogging in reducing plant height have been reported in other studies (Gutierrez Boem et al. 1996, Cannell and Belford 1980). In both years, crops grown on the flat were only approximately 70% the height of those grown on beds. Although not a problem in this experiment, further improvements of crop growth on raised beds may have implications for lodging.

Junkai et al. 2002 showed a relationship between weed occurrence characteristics and soil moisture content in rape. These authors showed plots suffering from light waterlogging to have the highest total weed yield compared to severely waterlogged and improved plots. In our experiment, there were higher weed burdens in the crops sown on the flat compared to raised beds. There were also more weeds in the earlier sown crops. Lower weed burdens in the July crops sown on raised beds were presumably due to the combination of the ability to remove late germinating weeds prior to sowing and greater competition from the crop due to the more vigorous crop growth on raised beds. Through the use of raised beds, the ability to sow crops later may provide more options for better weed control.
Reduced blackleg infection on the crops sown on beds in July may have been due to reduced susceptibility of healthier, more vigorous plants growing on the raised beds. The later sown crops may also have avoided climatic conditions conducive to spore release and exposure to high levels of inoculum.

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References