Wild radish-lupin competition: difference in the competitive ability of lupin cultivars

Abul Hashem1,3, Shahab Pathan2 and Bob French2,4
1 Department of Agriculture and Food Western Australia, Centre for Cropping Systems, PO Box 483, Northam, Western Australia 6401, Australia
2 Department of Agriculture and Food Western Australia, Dryland Research Institute, PO Box 432, Merredin, Western Australia 6415, Australia
3 CRC for Australian Weed Management
4 Centre for Legumes in Mediterranean Agriculture, The University of Western Australia, Crawley, Western Australia 6009, Australia

Summary Four trials were conducted in 2004 and 2005 at Merredin and Wongan Hills Research Stations in Western Australia to (1) examine the effect of wild radish (Raphanus raphanistrum L.) sown at various densities on the yield and quality of different lupin (Lupinus angustifolius L.) cultivars and (2) elucidate the mechanism of such competition. Results showed that competition from 3 to 28 wild radish plants m\(^{-2}\) in the lupin crop reduced lupin plant growth by 2 to 44%, grain yield by 16 to 66% and grain size by 2 to 7%. Wild radish grew significantly faster and the canopy was 35 to 50 cm taller than the lupin canopy during the reproductive stage. Thus, wild radish reduced photosynthetically active radiation (PAR) incident on lupins by up to 48%. Based on plant growth and grain yield, the cultivar Mandelup was a stronger competitor with wild radish than Belara, Tanjil or Tallerack. These results suggest that wild radish should be controlled at the vegetative stage to minimise competition and maximise lupin yield.

Keywords Wild radish, lupin cultivar, competition, biomass, photosynthetically active radiation, nutrients, grain yield, lupin grain size.

INTRODUCTION

Wild radish (Raphanus raphanistrum L.) is a very competitive weed with cereals and other winter crops (Cheam and Code 1995). It has evolved resistance to acetolactate synthase-inhibiting herbicides (Hashem et al. 2001a), photosystem II-inhibitors (Hashem et al. 2001b), carotenoid synthesis inhibitors (Cheam et al. 2000) and 2,4-D (Walsh et al. 2003) within WA wheatbelt. As few as four wild radish plants per square metre reduced canola (Brassica napus L.) yield by 9 to 11% and 64 wild radish m\(^{-2}\) reduced canola yield 77 to 91% (Blackshaw et al. 2002). Presence of 10 to 75 wild radish plants m\(^{-2}\) could reduce lupin (Lupinus angustifolius L.) yield by 28 to 92% in the WA wheatbelt (Hashem and Wilkins 2002).

It is important to know how competitive the new lupin cultivar Mandelup is, as it is expected to be adopted widely by WA growers over the next few years. This study was conducted to (1) examine the effect of wild radish sown at various densities on the yield and quality of different lupin cultivars and (2) elucidate the mechanism of such competition.

MATERIALS AND METHODS

Trials in 2004 Two trials were conducted on a deep sandy loam soil at Wongan Hills (30°51’S, 116°44’E) and loamy sand duplex soil at Merredin (31°27’S, 118°12’E) in Western Australia. Four densities of wild radish (0, 2, 10 and 20 plants m\(^{-2}\)) were grown with three lupin cultivars (Belara, Tallerack, and Tanjil) in a factorial complete block design with four replicates. The wild radish-free control was achieved by not introducing any wild radish pod segments. Any wild radish plants that emerged from the natural seed bank in the wild radish-free plots were hand-pulled at the vegetative and flowering stages. Wild radish was the dominant broadleaf weed species while annual ryegrass (Lolium rigidum Gaudin) was the dominant grass weed species in both locations. Grass weeds were controlled by clethodim 60 g a.i. ha\(^{-1}\) at the two tiller stage in both locations.

The wild radish-free control was achieved by not introducing any wild radish pod segments. Any wild radish plants that emerged from the natural seed bank in the wild radish-free plots were hand-pulled at the vegetative and flowering stages. Wild radish was the dominant broadleaf weed species while annual ryegrass (Lolium rigidum Gaudin) was the dominant grass weed species in both locations. Grass weeds were controlled by clethodim 60 g a.i. ha\(^{-1}\) at the two tiller stage in both locations.

Trials in 2005 Two trials were conducted at the same locations as described above including a new lupin cultivar Mandelup that has metribuzin tolerance.
Four densities of wild radish (0, 2, 10 and 20 plants m\(^{-2}\)) were grown with three cultivars of lupin (Belara, Mandelup and Tanjil) sown at two different times (early and late) in a split-plot design with three replicates. Cultivar \(\times\) sowing time combinations were assigned to the main plots and wild radish densities to sub-plots. Lupin was sown at 100 kg ha\(^{-1}\) in 23 cm wide rows on a unit plot size of 2 m \(\times\) 20 m in the 1st (early) and 3rd (late) weeks of May 2005 following standard agronomic practices, except that no pre-emergence simazine was applied. In both locations, dehulled wild radish seed was sown at rates calculated to achieve the target density at the same time as sowing lupins. All other cultural operations and the wild radish-free control plots were same as in 2004 trial.

**Measurements**

Wild radish density after emergence and at flowering stage of lupin was recorded from two 100 cm \(\times\) 50 cm fixed quadrats plot\(^{-1}\). Aboveground dry biomass of wild radish and lupin was recorded from the same quadrats at the flowering stage of lupin. Species canopy heights and photosynthetically active radiation (PAR) above the wild radish and lupin canopies were measured at the reproductive stage at mid-day on a sunny day, with a Sunfleck Ceptometer (CEO-UM-8). At harvest, lupin yield, grain size and grain protein contents were recorded. Plant growth and aboveground tissue nutrient content of wild radish and Mandelup lupin plants were also measured within a mixture of wild radish (10 plants m\(^{-2}\)) and lupin grown in separate plots at Merredin in 2005.

**RESULTS**

**Emergence and plant growth**

The achieved wild radish densities were higher than the target densities at both locations. A substantial reduction in crop biomass was observed due to competition from increasing wild radish density. For example, at Wongan Hills in 2005, lupin dry biomass was reduced by 19, 37 and 44% in Belara, 2, 20 and 16% in Mandelup and 24, 37 and 39% in Tanjil in the presence of 3, 14 and 28 wild radish plants m\(^{-2}\) respectively (Table 1). Mandelup suppressed wild radish growth 38 to 55% more and it suffered 17 to 24% less growth suppression from wild radish competition than the other cultivars at maximum biomass stage, regardless of wild radish densities. Mandelup was the strongest competitor at the flowering stage with less reduction in plant biomass than other cultivars.

**Canopy height, tissue macronutrients and radiation interception**

Wild radish grew faster and taller than lupins at the reproductive stage in mixture even though the lupin canopy was taller than wild radish during early vegetative stages (Figure 1). On average, wild radish plants were 35 to 50 cm taller than the lupin plant at maturity. Among the four lupin cultivars, Mandelup was 4 to 11 cm taller than Belara and Tanjil averaged over locations, sowing time and wild radish densities. Macronutrient concentrations (except N) in the aboveground tissue of wild radish were significantly higher than in lupins (data not presented). This fact might explain its ability to maintain higher growth rates than lupin (Figure 1).

**PAR at the top of the lupin canopy decreased with increasing wild radish density in each lupin cultivar at both locations (Figure 2).** For example, competition from 2 to 20 wild radish plants m\(^{-2}\) decreased available PAR by 16 to 48%, averaged over all cultivars.

**Table 1.** Effect of achieved wild radish density (plants m\(^{-2}\)) on the dry biomass (g m\(^{-2}\)) of wild radish and lupin plants measured at the maximum flowering stage of the lupin crop, averaged over two sowing times at Wongan Hills in 2005.

<table>
<thead>
<tr>
<th>Wild radish density</th>
<th>Wild radish dry biomass (g m(^{-2}))</th>
<th>Lupins dry biomass (g m(^{-2}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bel (^a)</td>
<td>Man</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>178</td>
<td>83</td>
</tr>
<tr>
<td>14</td>
<td>338</td>
<td>175</td>
</tr>
<tr>
<td>28</td>
<td>411</td>
<td>184</td>
</tr>
<tr>
<td>LSD</td>
<td>159</td>
<td>122</td>
</tr>
</tbody>
</table>

\(^a\) Bel = Belara; Man = Mandelup; Tan = Tanjil.

**Figure 1.** Plant height and dry biomass of lupin and wild radish grown in mixtures with 10 wild radish plants m\(^{-2}\) at Merredin in 2005. The vertical lines on the bars represent the standard error of the mean of three replicates.
Yield and grain quality  Lupin grain yield decreased significantly in all cultivars at both locations as wild radish density increased (Figure 3). In 2005 at Wongan Hills, three wild radish plants per square metre reduced lupin grain yield by 16 to 24% (Figure 3a). The presence of 28 wild radish plants m⁻² reduced lupin yield by 33 to 49%. The greatest grain yield was obtained from wild radish-free plots of Mandelup (2.31 t ha⁻¹), followed by Tanjil (2.14 t ha⁻¹), and then Belara (1.61 t ha⁻¹) at Wongan Hills, averaged over two sowing times. Mandelup suffered less yield loss than other cultivars at the same density of wild radish (Figure 3a). In 2005 at Merredin, lupin yields were very low (0.13 to 0.41 t ha⁻¹) and the wild radish competition effects were confounded by frost damage during pod set and high ryegrass populations in all treatments (data not presented).

In 2004 at Merredin, three wild radish plants per square metre reduced lupin grain yield by 27 to 46% (Figure 3b). The presence of 24 wild radish plants m⁻² reduced yield by 62 to 66%. The greatest grain yield was obtained from wild radish-free Tanjil (0.75 t ha⁻¹) followed by Tallrack (0.61 t ha⁻¹) and Belara (0.54 t ha⁻¹). However, Tanjil was a poorer competitor with greater loss of grain yield in the presence of 3 to 16 wild radish plants m⁻² than Belara and Tallrack (Figure 3b). In 2004 at Wongan Hills, lupin yields were very low (0.17 to 0.73 t ha⁻¹) and the wild radish competition effects were confounded by aphid infestations during the reproductive stage, particularly in the cultivar Tallrack (data not shown).

Lupin grain size was significantly reduced with increasing wild radish density, regardless of cultivar. For example, in 2005 at Wongan Hills, lupin grain size was reduced 3 to 5%, and in 2004 at Merredin, grain size was reduced 2 to 7% as wild radish density increased (data not shown).

Grain protein was not significantly affected by wild radish density in any lupin cultivar at either location. However, protein contents differed significantly among cultivars. Tanjil had the highest grain protein, followed by Mandelup, Tallrack and Belara, regardless of wild radish density (data not shown).

DISCUSSION
The yields in lupin cultivar Tallrack at Wongan Hills were confounded by an aphid infestation in 2004 and in all cultivars by a frost during pod set and high ryegrass populations in all treatments in 2005 at Merredin.

In other years and locations, lupin dry biomass was reduced by 2 to 44% and grain yield by 15 to 66% as wild radish density increased, regardless of cultivars and locations. The degree of reduction in lupin grain yield was much higher than the reduction in biomass.
due to wild radish competition, suggesting that competition was more intense during the reproductive stages than during the vegetative stage. These results indicate that wild radish was highly competitive with lupins at both locations. Hashem et al. (2004) found up to 59% yield loss of lupin grain in the presence of 20 wild radish plants m⁻² at Wongan Hills.

Regardless of cultivars, lupin grain size was reduced by 2 to 7% in presence of 3 to 28 wild radish plants m⁻². This reduction in grain size contributed to a reduction in lupin grain yield.

The lupin cultivar Mandelup produced 17 to 24% more lupin biomass and 30 to 40% more grain yield than Belara and Tanjil in the presence of 3 to 28 wild radish plants m⁻². It also suppressed wild radish growth by 38 to 55% more than Belara and Tanjil in the presence of 3 to 28 wild radish plants m⁻², indicating that this cultivar was a stronger competitor than Belara or Tanjil.

Lupin cultivar Mandelup was 4 to 11 cm taller than Belara, Tanjil or Tallerack. The wild radish canopy in mixtures was 35 to 50 cm taller and grew faster than lupin canopy during reproductive stages even though lupin canopy was taller than wild radish during the early vegetative stages (Figure 1). Such dynamics in canopy heights in a mixture of wheat and wild radish was also reported by Cousens et al. (2001). Available PAR on lupin canopy was reduced 16 to 54% by the presence of 2 to 20 wild radish plants m⁻². This suggests that competition from wild radish reduced grain yield and biomass of lupins mainly by reducing available PAR on the lupin canopy during the reproductive stage. Hashem et al. (2004) also found that competition from wild radish can reduce lupin grain yield and biomass by reducing available PAR.

The results of this study demonstrated that even three wild radish plants per square metre could reduce lupin yield by 16 to 46%. Mandelup is a stronger competitor with smaller reductions in plant growth and grain yield than Belara and Tanjil. Wild radish should be controlled at the vegetative stage to minimise competition and maximise lupin yield.

ACKNOWLEDGMENTS
We are grateful to the CRC for Australian Weed Management and the GRDC for funding this project. Special thanks are due to Professor Carol Mallory-Smith for previewing the paper.

REFERENCES