Competitive effects of wild radish (*Raphanus raphanistrum* L.) on lupin cultivars (*Lupinus angustifolius* L.)

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Abstract

Two trials were conducted in the Western Australian wheatbelt in 2005 to (i) examine the effect of wild radish (*Raphanus raphanistrum* L.) sown at various densities on the yield and quality of different lupin cultivars (*Lupinus angustifolius* L.) and (ii) elucidate the mechanism of such competition. Results showed that competition from 3 to 28 wild radish plants/m^2 reduced lupin grain yield by 15 to 49%. Early sown lupins were more competitive than late sown lupins, suffering less yield loss. Wild radish grew significantly faster than lupins during the reproductive stage, and its canopy was 35 to 50 cm taller. Thus, wild radish reduced photosynthetically active radiation available to lupins by up to 54%. The cultivar Mandelup is a stronger competitor with wild radish than Belara or Tanjil, with smaller reductions in plant growth and grain yield. We conclude that wild radish should be controlled at the vegetative stage to minimise competition and maximise lupin yield.

Key Words

competition, grain yield, grain size, photosynthetically active radiation, yield loss

Introduction

Wild radish **(***Raphanus raphanistrum* L.**)** is a very competitive weed with cereals and other winter crops (Cheam and Code 1995). It can reduce lupin growth and productivity by competing for light, soil water and nutrients. Its seed bank can last as long as six years under continuous cropping systems such as a wheat-lupin rotation (Hashem 2006). It is a major threat to the production of cereals, canola, lupins, and other pulses in the Western Australian (WA) wheatbelt. This weed has evolved widespread resistance to acetolactate synthase-inhibiting herbicides (Hashem *et al*. 2001a), photosystem II-inhibitors such as simazine and atrazine (Hashem *et al.* 2001b), carotenoid synthesis inhibitors such as diflufenican (Cheam *et al.* 2000) and 2,4-D (Walsh *et al*. 2003) in the WA wheatbelt. Competition from 3 to 24 wild radish plants/m^2 can reduce lupin yield by 27 to 66% (Pathan *et al.* 2005). As few as 4 wild radish plants/m^2 reduced canola yield by 9 to 11% and 64 wild radish plants/m^2 reduced canola yield 77 to 91% (Blackshaw *et al.* 2002).

The consequences of wild radish competition on lupin in WA have been previously reported (Pathan *et al.* 2005; Hashem *et al.* 2004). However, it is important to determine the competitive ability of the new lupin cultivar Mandelup which is expected to be widely grown in WA. Two trials were conducted at the Merredin and Wongan Hills Research Stations in 2005 to (i) examine the effect of wild radish sown at various densities on the yield and quality of different lupin cultivars and (ii) elucidate the mechanism of such competition.

Methods

Two trials were conducted; one on a deep sandy loam at Wongan Hills (30?51' S; 116?44' E) and one on a loamy sand at Merredin (31?27' S; 118?12' E) in Western Australia (WA). Four densities of wild radish (0, 2, 10 and 20 plants/m^2) were combined with three lupin cultivars (Belara, Mandelup and Tanjil) sown at two different times (early and late). Treatments were laid out in a split-plot design with three replicates. Cultivars x sowing time combinations were assigned to the main plots and wild radish densities to sub-plots. Lupins were wet sown at 100 kg/ha in rows 23 cm apart in plots of 2 m x 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 de-hulled wild radish seed was sown at the same time as lupins at rates calculated to achieve the target density.

The wild radish-free control was achieved by not sowing any wild radish seed. Any wild radish plants that emerged from the natural seed bank in the wild radish-free plots were hand-pulled. Wild radish was the dominant broadleaf weed species present while annual ryegrass (*Lolium rigidum* Gaudin) was the dominant grass weed species at both locations. Grass weeds were controlled with clethodim 60 g a.i./ha at the 2-tiller stage of ryegrass at both locations, although it was not very successful at Merredin. No post-emergence herbicides were sprayed to control broadleaf weeds at either location.

Measurements

Wild radish and lupin density after emergence, and at the flowering stage of lupin, was recorded from two 100 cm x 50 cm fixed quadrats in each plot. Aboveground dry biomass of wild radish and lupin was recorded from the same quadrats at the flowering stage of lupin. Canopy heights of each species were measured at the reproductive stage of lupin, as well as photosynthetically active radiation (PAR) above the wild radish canopy and above the lupin canopy with a Sunfleck Ceptometer (CEO-UM-8). At harvest, lupin yield, grain size and grain protein contents were recorded. Plant growth of wild radish and Mandelup lupin plants were also measured within a mixture of wild radish (10 plants/m?) and lupin grown in separate plots during the growing season at Merredin.

Results

Plant emergence and growth

The observed wild radish densities were higher than the target density at both locations (Table 1). Wild radish competition did not affect lupin plant emergence (Table 1). However, a substantial reduction in crop biomass due to competition from increasing wild radish density was observed at both sites. At Wongan Hills, lupin dry biomass was reduced at flowering by 7, 23 and 34% in Belara; 1, 2, 18% in Mandelup; and 11, 18 and 27% in Tanjil in the presence of 3, 14 and 28 wild radish plants/m^2 respectively.

Table 1. The density of wild radish and lupins observed at 6 weeks after seeding at Merredin and Wongan Hills, averaged over both sowing times and all cultivars.

Target wild radish density (plants/m^2)	**Observed wild radish density (plants/m^2)**		**Observed lupin density (plants/m^2)**	
	Merredin	Wongan Hills	Merredin	Wongan Hills
0	0	0	46	55
2	5	3	48	54

10	24	14	48	55
20	43	28	47	53
LSD (P=0.05)	5	3	ns*	ns

*ns = not significant.

Canopy height and radiation interception

Wild radish grew faster and taller than lupins in the mixture after the lupins flowered, even though the lupin canopy was taller before flowering (Figure 1). On average, wild radish was 35 to 50 cm taller than lupins at maturity. Mandelup (~62 cm) was 4 to 5 cm taller than Belara (~58 cm) and Tanjil (~57 cm), averaged over both locations.

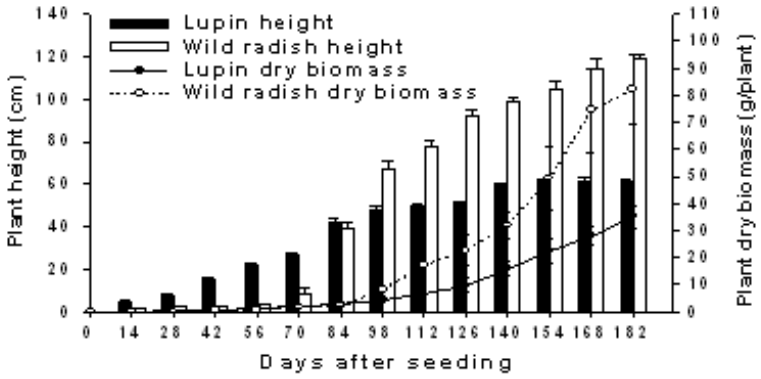

Figure 1. Plant height and dry biomass of lupin and wild radish grown in mixtures with 10 wild radish plants/m? during growing season at Merredin.

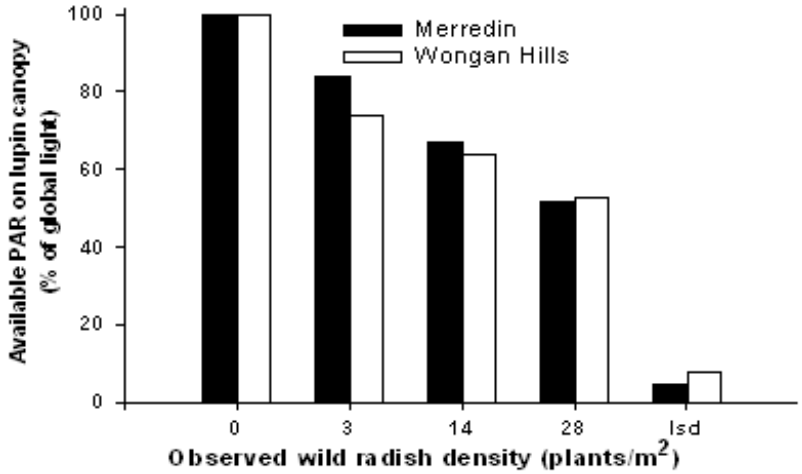

Figure 2. Effect of observed wild radish density on the available photosynthetically active radiation (PAR) at the top of lupin canopy measured at mid-day on a sunny day at Merredin and Wongan Hills at the late flowering stage of lupin, averaged over all cultivars.

The available PAR at the top of the lupin canopy decreased with increasing wild radish density at both locations (Figure 2). Averaged over all cultivars, competition from 3 to 28 wild radish plants/m^2 decreased available PAR by 16 to 54% (Figure 2).

Yield, yield loss and grain quality

Lupin grain yield decreased significantly in each cultivar as wild radish density increased at both locations. At Wongan Hills 3 wild radish plants/m^2 reduced lupin grain yield by 15 to 24% (Figure 3a). The presence of 28 wild radish plants/m^2 reduced yield by 33 to 49%. At Wongan Hills the highest grain yield was obtained from wild radish-free plots of Mandelup (2.31 t/ha), followed by Tanjil (2.14 t/ha) and Belara (1.61 t/ha). Mandelup also suffered less yield loss than other cultivars at the same density of wild radish (Figure 3a). The yield loss from wild radish competition was greater with late than with early sowing (Figure 3b).

Seed size differed significantly between cultivars at each location. Mandelup was largest (138-144 g/1000 seed), followed by Belara (125-139 g/1000 seed) and, finally, Tanjil (122-127 g/1000 seed). This effect was consistent across wild radish densities and locations. No definite pattern of the impact of wild radish density on grain protein content of lupin was observed. However, grain protein contents differed significantly between cultivars. Tanjil had the highest grain protein (34.1-34.3%), followed by Mandelup (32.4-34.0%) and Belara (32.6-33.2%).

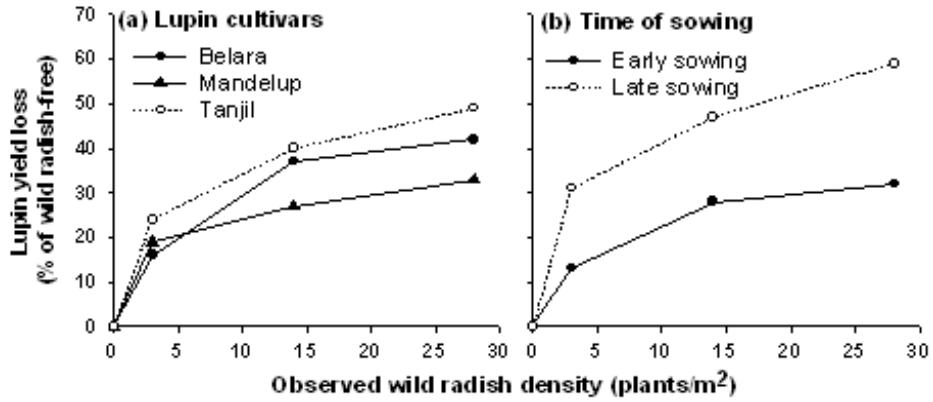

Figure 3. Effect of observed wild radish density on the grain yield loss (% of wild radish-free) of different lupin cultivars at (a) three lupin cultivars and (b) two sowing times at Wongan Hills.

Discussion and Conclusions

Lupin dry biomass and grain yield were drastically reduced by an increase in wild radish density in all cultivars and at both locations. The reduction in lupin grain yield due to wild radish competition was much higher than the reduction in biomass at flowering, suggesting that competition was more intense during the reproductive stages than during the vegetative stage. 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. Lupin cultivar Mandelup produced 30 to 40% more grain yield than Belara and Tanjil in the presence of 3 to 28 wild radish plants/m^2. Mandelup also suffered less yield loss than other cultivars at the same density of wild radish (Figure 3a), indicating that this cultivar was a stronger competitor than Belara or Tanjil.

In mixtures the wild radish canopy was 35 to 50 cm taller and grew faster than the lupin canopy during the reproductive stage even though the lupin canopy was taller earlier. Such dynamics in canopy heights in a mixture of wheat and wild radish was reported by Cousens *et al.* 2001. 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 (Figure 2). Hashem *et al*. (2004) also showed that competition from wild radish could reduce lupin grain yield and biomass by reducing available PAR.

This study demonstrates that wild radish is highly competitive with lupins. Nevertheless, Mandelup is a stronger competitor than Belara or Tanjil, with smaller reductions of plant growth and grain yield. Therefore, lupin cultivars differ in competitiveness against wild radish. Mandelup also showed highest yielding ability in the absence of weeds which should make this cultivar attractive to the growers in WA. Early sown lupins were more competitive than late sown lupins and suffered less yield loss. This information has important implications for managing wild radish. It should be controlled at the early vegetative stage to minimise competition and maximise lupin yield.

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