Terminal Drought and Seed Yield of Lupin

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ABSTRACT

Lupin is the main pulse crop grown in the mediterranean climatic region of Australia, but the crop frequently encounters terminal drought. As a consequence, seed yields are reduced. Studies over two consecutive seasons with several lupin genotypes showed that the narrow-leafed lupin cultivars Belara and Tellarack, and the breeding line WALAN2049 outyielded Merrit, the most commonly grown cultivar in Western Australia. These genotypes also maintained harvest index when grown under rainfed conditions at Merredin, Western Australia. When grown under a rainout shelter the cultivars Belara, Tanjil and Quilinock also outyielded Merrit. A common characteristic of these genotypes was that they set fewer pods than Merrit, but the survival of pods and seeds was greater under terminal drought.

KEY WORDS

Lupinus angustifolius, yield performance, drought tolerance, lupin genotypes, seed filling, pod retention.

INTRODUCTION

Lupin is a rainfed crop in the Mediterranean climatic region of Australia where drought terminates the growing season. Although lupin flowers early (7), the subsequent vegetative growth delays the start of pod filling until terminal drought develops (2,6). Terminal drought reduces pod filling through a reduction in the availability of carbon and nitrogen resources (3,1), which causes pod and seed abortion and therefore a reduction in seed yield (4,1). Consequently, pod retention and seed filling are likely characteristics to consider in drought tolerant lupins (5). Over the past three years, research has been conducted in Western Australia to evaluate lupin genotypes for their seed yield and harvest index under terminal drought against Merrit, the most common cultivar grown in Western Australia. This paper summarises their yield performance and the characteristics that confer tolerance to terminal drought.

MATERIALS AND METHODS

Field experiments were conducted over the May-December growing season of 1998 and 1999 at Merredin, Western Australia. In the season of 1998, six lupin genotypes were grown in a split-plot design with two watering treatments as main plots, and genotypes randomised as subplots in 4 blocks within each main-plot. Experimental plots were 1.44 m wide, 40 m long. The lupins were rainfed until podding, after which half of the plots were irrigated by drip irrigation to replace evaporation as required, and the other half were rainfed until maturity. In the season of 1999, nine lupin genotypes were grown in plots that were 1.08 m wide, 10 m long. The lupins were also rainfed until podding, after which half of the lots were irrigated to replace evaporation as required, and a rainout shelter was moved over the other half whenever it rained so that all rainfall after podding commenced was excluded until maturity, ensuring conditions of terminal drought.

RESULTS

In the growing season of 1998 when lupin genotypes were grown under rainfed (217 mm) and irrigated conditions, seed yield varied from 1.2 - 2.2 t/ha under rainfed conditions and from 1.9 – 3.1 t/ha under irrigation. (Table 1). Seed yield of cultivars Belara and Tellarack, and the breeding line WALAN2049 exceeded that of Merrit by 23-29% when grown under rainfed conditions and by 12-18% when grown under irrigation. Final biomass was similar among the six genotypes under both rainfed and irrigation, but the harvest index of Belara was 14% higher than that of Merrit under rainfed and irrigated conditions. Belara also had the largest final seed size, the fastest rate of seed growth and the shortest duration of seed filling (data not shown) under both rainfed and irrigated conditions.

Table 1. Yield performance of 6 lupin genotypes grown in 1998 at Merredin under rainfed and irrigated conditions from the commencement of podding. ^{A}Refers to *Lupinus angustifolius,* ^{L}refers to *Lupinus luteus.*

Genotype	Seed yield (t/ha)	Biomass (t/ha)	HI (%)	Seed size (mg/seed)	Seed growth rate (mg/day)
		Rainfed			
Merrit^{A}	1.7	4.7	36	154	5.4
Belara^{A}	2.2	5.3	41	170	7.0
Tallerack^{A}	2.0	5.6	37	155	6.7
WALAN 2049^{A}	2.0	5.5	37	168	6.4
Myallie^{A}	1.7	5.2	34	168	6.0
Wodjil^{L}	1.2	5.1	24	161	6.2
l.s.d(P<0.05)	0.2	0.9	2	9.0	0.8
		Irrigated			
Merrit^{A}	2.7	7.4	36	168	5.9
Belara^{A}	3.2	7.8	41	194	7.3
Tallerack^{A}	3.0	8.0	38	169	6.1
WALAN 2049^{A}	3.0	7.9	39	182	7.1
Myallie^{A}	2.8	8.1	34	176	6.2

Wodjil[L]	2.0	8.2	24	168	6.5
l.s.d(P<0.05)	0.3	0.9	3	14	0.7

In the 1999 growing season when nine lupin genotypes were grown rainfed (225 mm) and under a rainout shelter (160 mm), seed yield varied from 1.3 - 2.3 t/ha under the rainout shelter and from 2.4 – 3.6 t/ha under irrigation (Table 2). The seed yield of cultivars Belara, Quilinock and Tanjil were 30%, 34% and 48% higher, respectively, than that of Merrit under the rainout shelter and 48% and 33% under irrigation. Final biomass of these cultivars was also higher than in Merrit, but their harvest index was similar, to Merrit, irrespective of whether they were under the rainout shelter or irrigated. None of the advanced breeding lines had seed yields that exceeded the yields of Belara, Quilinock and Tanjil. The newly released cultivar Quilinock had the highest pod retention at 90% under irrigation and 80% under the rainout shelter. All the advanced breeding lines had low pod retention characteristics under the rainout shelter.

DISCUSSION

The genotypes chosen in this study represented those with putative differences in seed yield in low rainfall areas of Western Australia and the treatments imposed after podding commenced were used to measure their yield performance under rainfed and rainout shelter conditions. It is recognised that the seed filling and seed yield of the lupin genotypes under rainfed and under the rainout shelter were affected by the intensity of development of the water deficit (4,1), since the yields of Merrit, Belara and Wodjill, the common cultivars in each year, were higher under rainfed than under the rainout shelter conditions.

The higher seed yields of the narrow-leafed lupin cultivars Belara, Tellarack and breeding line WALAN 2049 under rainfed conditions resulted mainly from a greater survival of their pods and seeds, but not from more pods been set. Pod set in these genotypes was lower than in Merrit (data not shown), indicating that the seed yield of lupin genotypes with better seed and pod survival are likely to be less affected by terminal drought. Belara is a large-seeded cultivar released in 1997 (B. Buirchell, personal communication) and its seed size was higher than that of Merrit under rainfed conditions. Detailed measurements of seed development showed that the higher seed size of Belara under rainfed conditions resulted from fast rates of seed growth and a short duration of seed filling (data not shown).

Table 2. Yield performance of 9 lupin genotypes grown under terminal drought and irrigation conditions from the commencement of podding. [A]Refers to *Lupinus angustifolius,* [L]refers to *Lupinus luteus*

Genotype	Seed yield (t/ha)	Biomass (t/ha)	HI (%)	Pod retention (%)
		Rainout Shelter		
Merrit[A]	1.5	5.5	28	62
Tanjil[A]	2.3	8.4	28	80
Quilinock[A]	2.0	7.5	28	80

Belara[A]	2.0	7.4	28	67
WALAN2053[A]	1.9	7.3	27	69
Kalya[A]	1.8	6.5	28	75
WALAN2026[A]	1.7	6.4	28	63
WALAN2072[A]	1.7	6.5	27	66
Wodjil[L]	1.3	6.2	21	32
l.s.d(P<0.05)	0.4	1.5	2.4	3.6
		Irrigated		
Merrit[A]	2.4	8.8	27	54
Tanjil[A]	3.6	12.2	30	72
Quilinock[A]	3.2	11.0	29	90
Belara[A]	3.0	9.9	30	68
WALAN2053[A]	2.0	7.3	27	51
Kalya[A]	2.6	9.2	28	57
WALAN2026[A]	2.6	8.7	30	80
WALAN2072[A]	2.6	9.4	28	79
Wodjil[L]	3.1	12.3	25	74
l.s.d(P<0.05)	0.4	0.9	3.0	2.4

The low seed yield of Merrit under rainfed conditions was associated with the smallest final seed size, the slowest seed growth rate and the longest duration of seed growth (data not shown). This indicates that a faster rate of seed growth is an important characteristic to maintain seed size in lupin under rainfed conditions.

The higher seed yields of the narrow-leafed lupin cultivars Tanjil and Quilinock under the rainout shelter were associated with a high pod retention, indicating that pod retention under terminal drought was likely an important yield-related characteristic (5). However, pod retention was not the only important yield-related characteristic, since Belara had a seed yield that was similar to that of Tanjil and Quilinock, but its pod retention was lower. Analysis of the components of seed yield, which is not shown here, indicates that the high seed number per pod and seed size of Tanjil, Quilinock and Belara under terminal drought made also an important contribution in maintaining seed yield.

CONCLUSION

This study has demonstrated that the fast rate of seed growth in the narrow-leafed cultivars Belara, Tallerack and WALAN 2049 was an important characteristic that maintained seed filling and seed yield under rainfed conditions. High pod retention was also an important yield-related characteristic in cultivars Tanjil and Quilinock under rainout shelter conditions. Their seed number per pod and seed size under terminal drought were also important characteristics determining seed yield.

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