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Lupin studies in the Emerald Irrigation Area

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Summary

In lupin cultivar trials conducted in each of the years 1975 to 1977 in the Emerald Irrigation Area (EIA), Ultra and Kiev Mutant (*Lupinus albus*) and Unicrop (*L. angustifolius*) gave the highest yields. A mid April sowing gave highest yields compared to sowings one month before or after in a time of sowing x cultivar trial. Ultra and CPI 47643 yielded higher ($P < 0.05$) than Unicrop in this trial. In a phosphorus rates, pot trial conducted in 1980 using EIA soil and cv. Unicrop, a significant ($P < 0.05$) linear response to applied phosphorus was measured in root, shoot and nodule dry matter production.

Experimental yields of 3000 kg/ha under irrigation would be necessary before commercial production could be contemplated. In our series of experiments such yields were not achieved. Further lupin research in the EIA should concentrate on *L. albus* cultivars and determine more precisely their phosphorus and time of sowing requirements.

INTRODUCTION

Lupin is a winter growing legume producing seed with a crude protein analysis of 28 to 48% (Hill 1977). The seed requires no heat treatment prior to livestock feeding. Lupins have become established as a successful raingrown crop in southern Australia following breeding by Dr. J. S. Gladstones of the Western Australian Department of Agriculture.

Raingrown and irrigated trials have been conducted at a number of Queensland locations (Hall *et al.* 1984). Irrigated trials at Biloela Research Station in the Callide Valley, central Queensland, on an alluvial cracking clay (Ug 5.15, Northcote 1971), have demonstrated the potential of certain lupin varieties in that region (Jackson *et al.* 1986). No information exists on the potential of lupins in the Emerald Irrigation Area (EIA), which is the other major irrigation area in central Queensland. High spring temperatures (mean daily maximums above 28°C), high clay content (60 to 80%) and the moderately alkaline nature(pH 7.9 to 8.5) of the major soil type differentiates the EIA environment from that of lupin production areas in southern Australia. The EIA also differs measureably from the Callide Valley, having mean daily maximum temperatures 2 to 3°C higher and clay contents approximately 20% higher.

A series of trials including cultivar and time of sowing × cultivar trials were conducted at Emerald (23°28′S, 148°9′E) from 1975 to 1979 to provide information on lupin adaptation in the EIA. In 1980, a pot trial using soil from the EIA was conducted at Biloela Research Station to assess the response of the cultivar Unicrop to added phosphorus.

MATERIALS AND METHODS

Species and cultivar evaluation, 1975–1977

Trials were conducted on McCosker's Lease 1 km south of Emerald. The soil type at this site is an open downs, cracking clay (Ug 5.12, Northcote 1971).

Details of the cultivars, species and sowing dates are listed in Table 1. A randomised, complete block design was used for all trials. Plots consisted of three 1 m wide beds each containing 5 rows, 9 m long and 0.18 m apart. Prior to sowing in 1975 and 1976, a basal

fertiliser application (10 N, 21.5 P, 12.5 K kg/ha) was dispersed throughout the top 10 cm of soil. In 1977 the basal fertiliser was changed to 40 P, 48 K, 17 Zn and 0.3 Mo kg/ha.

Table 1. Sowing dates and cultivars of various *Lupinus* species in trials conducted in the Emerald Irrigation Area in each of the years 1975–77

Sowing date	*Lupinus* spp.	Cultivars
20 May 75 and 12 April 76	*L. albus*	Ultra, Hamburg
	L. angustifolius	Unicrop, Uniharvest
27 April 77 and 10 June 77	*L. albus*	Ultra, Hamburg, Kiev Mutant
	L. angustifolius	Unicrop
	L. cosentinii	Eregulla
	L. luteus	Weiko III, Sulfa

Seed of cv. Eregulla was acid treated (Horn and Hill 1974) to remove its inherent hard-seededness. Seed of all cultivars were inoculated with *Rhizobium* strain WU 425 inoculant and sown through a cone planter into dry soil. A 50 mm furrow irrigation was applied immediately after sowing. Further 50 mm applications were applied until the end of pod filling at intervals when a water deficit of 50 mm had accumulated (summation of 0.8 daily pan evaporation minus rainfall). Hand thinning to a population of 25 plants/m^2 was carried out two weeks after emergence. At maturity, 8 m of the centre bed was harvested.

Phenological data including time to flower, duration of flowering and time to maturity were recorded for each cultivar in each year. Plant heights of all cultivars were measured at maturity. Grain weights were determined by weighing two, 200 grain samples selected at random from each plot. Kjeldahl nitrogen measurements were converted to protein percentage by multiplying by 6.25.

Time of sowing × cultivar trial, 1979

Unicrop, Ultra and CPI 47643 (low alkaloid genotype of *Lupinus albus*) were included in a time of sowing trial at the Emerald Research Station, 2 km north of Emerald on a soil type similar to that at McCosker's Lease. Sowing times of March 20, April 13 and May 28 were randomly allocated to the main plots of a randomised block layout replicated twice. Each main plot was split for the three cultivars. Split plot dimensions, irrigation scheduling and data collection methods except for phenological data were similar to those used in the cultivar evaluation trials. Only time to flowering was measured as terminal death to many of the lateral branches during budding caused an atypical flowering pattern. The same basal fertiliser as used in the 1977 cultivar trial was applied.

Phosphorus study, 1980

A phosphorus study using rates of 0, 40, 80, 160 kg P/ha added as $Ca(H_2PO_4)_2 H_2O$ was conducted in pots in a shadehouse at Biloela. Unfertilised soil adjacent to the 1979 Emerald time of sowing × cultivar trial (8.5 ppm bicarbonate P) and an unfertilised alluvial soil (130 ppm bicarbonate P) from Biloela Research Station were used. Basal nutrients other than phosphorus were added in solution to all pots at rates sufficient to overcome nutrient deficiencies in the Emerald soil. A randomised block design with three replicates was used to test the response of cv. Unicrop to the added levels of phosphorus in the two soils. Seedlings were thinned to one plant per pot one week after emergence. Pots containing 1.3 kg of soil were maintained at a constant water table (2.5 cm at 24 cm below the soil surface) throughout the trial. Plants were harvested 72 days after sowing and dry matter of various plant components was measured.

Statistical methods

Data were analysed using the analysis of variance technique with the protected l.s.d. procedures to test for treatment differences at $P = 0.05$.

RESULTS

Climatic data for the seasons in which field trials were successfully completed are presented in Table 2. The main features observed from the climatic data are the relatively mild winter temperatures and the rapid rise in average maximum temperatures in the spring.

Table 2. Climatic data for irrigated lupin trials successfully conducted in the Emerald Irrigation Area

Month	Years														
	Mean daily max temp (°C)					Mean daily min temp (°C)					Total rainfall (mm)				
	1975	1976	1977	1979	LTA*	1975	1976	1977	1979	LTA	1975	1976	1977	1979	LTA
March	31.9	32.2	31.7	31.3	32.5	20.9	21.0	20.5	19.9	19.3	60.5	47.8	125.7	78.8	69.5
April	27.3	28.8	30.0	30.7	29.9	15.9	16.3	17.9	16.3	15.2	13.2	17.2	1.0	21.5	33.3
May	27.2	26.1	25.7	26.0	26.2	10.3	13.4	14.2	12.5	11.1	0.0	13.3	130.7	6.1	27.0
June	22.9	22.9	22.4	24.5	23.1	9.1	7.6	8.0	10.4	8.6	39.0	7.8	3.4	14.2	31.5
July	24.8	22.5	22.3	22.9	22.7	9.8	8.6	7.3	7.3	6.8	22.1	18.1	7.1	0.0	30.8
August	25.4	24.0	25.8	26.3	25.1	9.5	6.5	8.0	9.1	7.5	5.8	5.6	3.0	4.2	13.5
September	28.2	28.2	28.4	29.2	28.4	15.2	12.1	10.9	14.2	11.8	27.3	16.5	5.2	3.0	17.3
October	30.0	30.7	33.3	32.7	32.1	16.8	15.2	15.8	17.4	15.8	91.8	60.5	0.0	12.6	41.0
November	33.9	34.6	34.6	35.3	34.2	18.6	20.0	19.9	20.3	18.9	42.1	19.6	55.6	48.6	69.8

* Long term average

Yield and plant height data for the cultivar trials are presented in Table 3. Only Ultra, Hamburg and Kiev Mutant emerged satisfactorily in April 1977. In June 1977, observation plots of Weiko III and Sulpha were sown to provide phenological data only, because of insufficient seed.

Table 3. Yield, seed quality (at 12% moisture content) and plant height data for lupin cultivars sown in May 1975, April 1976, April 1977 (A) and June 1977(B) at McCosker's Lease in the Emerald Irrigation Area

Cultivar	Plant height (cm)				Protein (%)				Grain wt (mg/seed)				Grain yield (kg/ha)			
	1975	1976	1977		1975	1976	1977		1975	1976	1977		1975	1976	1977	
			A	B			A	B			A	B			A	B
Ultra	68	101	109	62	32.6	33.3	29.5	28.4	213	365	369	310	1127	2291	2238	1201
Hamburg	105	136	138	79	32.0	33.1	31.3	29.3	164	351	337	277	368	1660	1594	881
Kiev Mutant			107	58			30.1	30.5			371	321			2285	1319
Unicrop	61	74		51	32.5	32.3		28.5	136	166		175	1073	2107		1337
Uniharvest	90	164			27.1	30.3			84	122			7	51		
Eregulla				78				28.2				227				738
Weiko III*				55												
Sulfa*				51												
l.s.d. (P = 0.05)	4.8	6.1		4.6	1.9	2.7	1.2	2.5	11.5	13.5	35.5	18.5	141	218	443	181

* Observation plots only

Ultra, Kiev Mutant and Unicrop gave highest seed yields and protein contents. The effect of delayed planting date on flowering and the effect of a vernalisation requirement for flowering in Hamburg, Uniharvest and Eregulla are shown in Figure 1. The April sowing date in 1976 when compared to the May sowing date in 1975 resulted in higher

yields and taller plants. This trend was again evidenced in the 1977 data if yields and plant heights of the three cultivars common in the two 1977 sowings are compared.

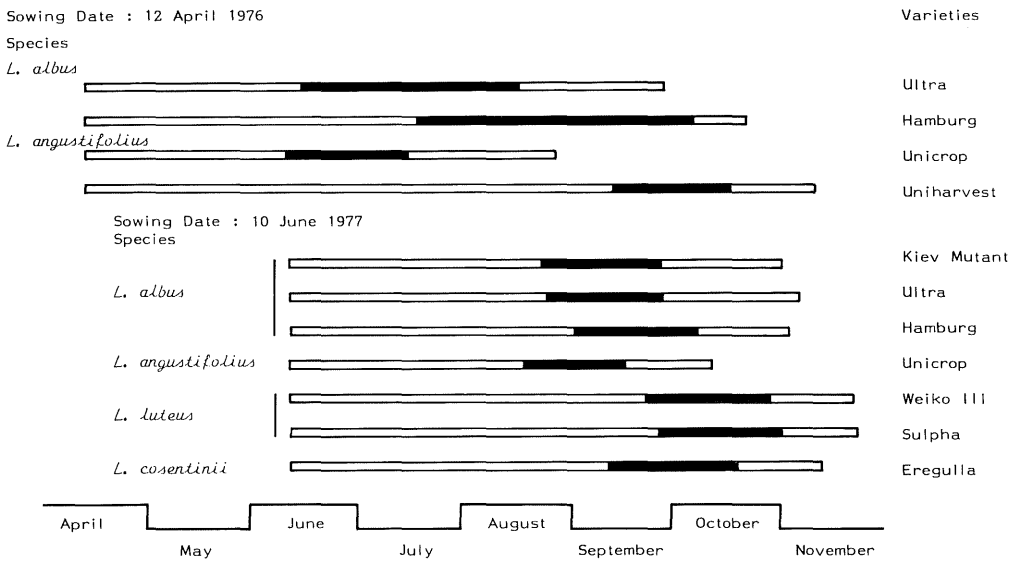

Figure 1. Duration of the periods: a, sowing to flowering; b, flowering and c, flowering to maturity for varieties within various lupin species at different sowing dates in 1976 and 1977 at Emerald.

Results of the time of sowing × cultivar trial are presented in Table 4. The April sowing gave the highest yield and was significantly higher ($P < 0.05$) than the May sowing. Days to flower increased as sowing date was delayed. This indicates that lower temperatures and not vernalisation as the major factor influencing flowering in varieties included in this trial. The main cultivar effect was that Ultra and CPI 47643 were superior ($P < 0.05$) to Unicrop in seed yield. The analysis for comparing varieties within a particular sowing time is not presented. In each time of sowing, seed yield for Unicrop was significantly lower ($P < 0.05$) than Ultra and CPI 47643.

Table 4. Effect of sowing time and variety on seed yield, seed weight, protein content (at 12% moisture content) and plant height of lupins at Emerald Research Station, 1979

Factor	Character	Planting date			l.s.d. (P=0.05)
		Mid March	Mid April	Mid May	
Sowing time					
	Seed yield (kg/ha)	748	893	505	370
	Grain wt (mg/seed)	264	268	222	9
	Protein (%)	33.7	34.0	37.6	n.a.*
	Plant height	44.5	44.8	38.2	n.a.
	Days to flower	57	67	72	n.a.
Variety		Unicrop	Ultra	CPI 47643	l.s.d. (P=0.05)
	Seed yield (kg/ha)	342	883	921	200
	Grain wt (mg/seed)	136	303	314	22
	Protein (%)	32.3	36.2	36.6	n.a.
	Plant height (cm)	23.7	50.3	53.5	4.1
	Days to flower	60	69	67	n.a.

* not analysed

Dry matter production responses of shoot and root components to added phosphorus rates are presented in Figure 2. An addition of 40 kg P/ha to the Biloela soil had no effect

($P < 0.05$) on dry matter production of any of the components measured. Significant ($P < 0.05$) linear responses to added rates of phosphorus were recorded for all measured dry matter components in the Emerald soil. Severe symptoms of phosphorus deficiency including lower leaf drop and terminal death of lateral branches were apparent in the OP treatment in the Emerald soil.

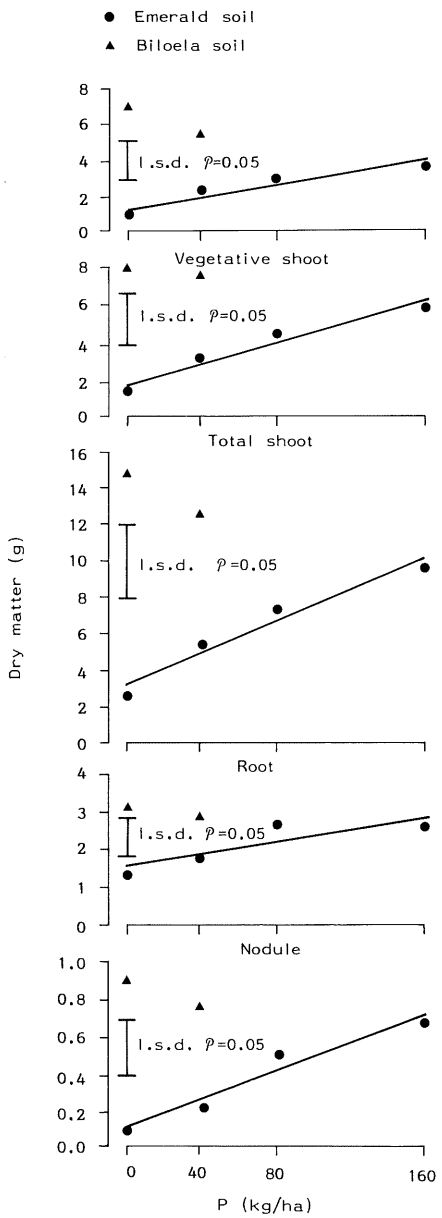

Figure 2. Effect of phosphorus rates on dry matter production of shoot and root components of lupin cv. Unicrop grown in Emerald and Biloela soil 73 days after sowing.

DISCUSSION

L. albus and *L. angustifolius* cultivars with yields of 2100 to 2300 kg/ha were most successful in these studies. We believe experimental yields of at least 3000 kg/ha are necessary before commercial production could be recommended.

The main climatic constraint to lupin production in the EIA is the rapid rise in temperature in spring. There is a 50% chance that weekly mean maximum temperatures will rise above 28°C by mid September (Rosenthal and Hammer 1979). *L. albus* cultivars appear to have the most potential to succeed in this environment. The species can tolerate temperatures up to 28°C during flowering (Withers and Edge 1979) whereas temperatures above 25°C during flowering are detrimental to podset in *L. angustifolius* (Corbin 1978). By sowing *L. albus* cultivars having little or no vernalisation requirement in April, flowering is completed before mid September (Figure 1). This is substantiated by the relative success of the April sowing in the time of sowing × cultivar trial. The greater tolerance of *L. albus* to calcareous soils (Gladstones 1970) compared to other *Lupinus* species also suggests that this species has greatest potential because of the calcareous nature of the cracking clays in the EIA.

Lower yields at the Emerald Research Station compared to those obtained at McCosker's Lease are attributed to a lower phosphorus level at the former site. Phosphorus levels (bicarbonate extract) determined after harvest of the 1979 trial were 11.5 ppm in the trial site and 8.5 ppm adjacent to the trial site. The higher phosphorus level (22 ppm) measured at McCosker's Lease at the same time was attributed to fertiliser applications over several years.

Phosphorus levels below 10 ppm are common in the cracking clays in the EIA. Phosphorus rate experiments with guar (*Cyamopsis tetragonoloba*) on a long fallow site at the Emerald Field Station gave a similar response to that measured in lupin (K. Jackson unpub. data 1984). In other phosphorus rate experiments at the same place, sunflower (*Helianthus annus*) responded only in a long fallow site (D. Hibberd and M. Hunter, pers. comm. 1984). Nil response in a short fallow site was associated with greater activity of Vesicular Arbuscular Mycorrhiza (VAM). Trinick (1977) considered that VAM were of little value in phosphorus uptake in *Lupinus* spp. on the phosphorus deficient soils of Western Australia. It is possible that lupins may not benefit from a symbiotic relationship with VAM in the EIA soils, and may have to rely solely on added phosphorus for reliable yields.

Lupin research was discontinued in central Queensland in 1981 due to low lupin grain prices and changing research priorities. Any future lupin research in the EIA. should include further time of sowing studies with *L. albus* cultivars. Phosphorus rate × placement studies and the determination of the role of VAM in phosphorus nutrition of lupins are also warranted.

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