Iraq Project Meeting ICARDA
September 2005

Title:
'A decade of research on cool season grain legumes in dryland environments: lessons learned'

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This version developed 24 August 2005

A DECADE OF RESEARCH ON COOL SEASON GRAIN LEGUMES IN DRYLAND ENVIRONMENTS: LESSONS LEARNED

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Outline of Presentation

- Background
- Pulse species and adaptation
- Production agronomy
- Genetic improvements
- Conclusions

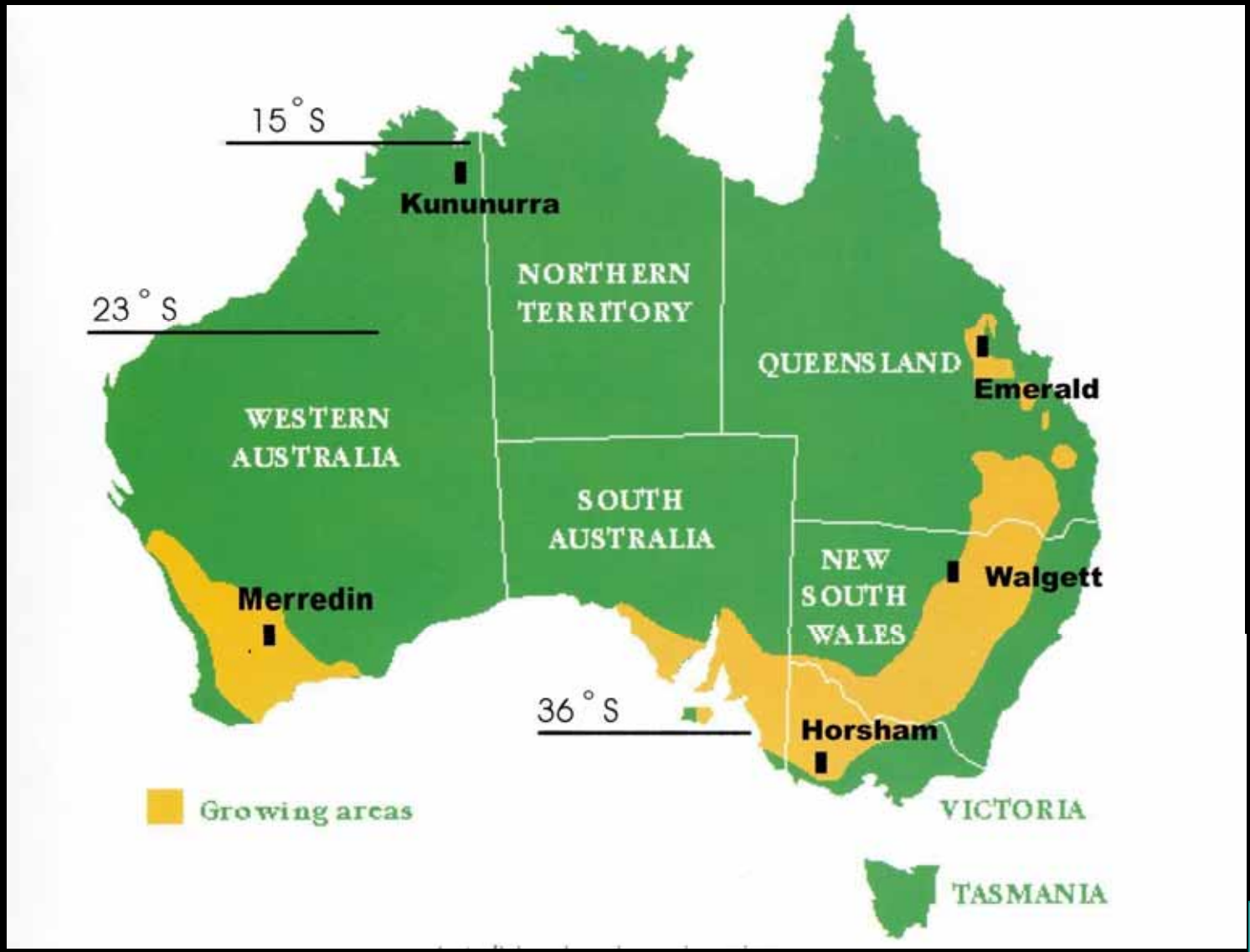
1. Background

Current cool- and warm-season grain legume crop species of commercial significance in Australia

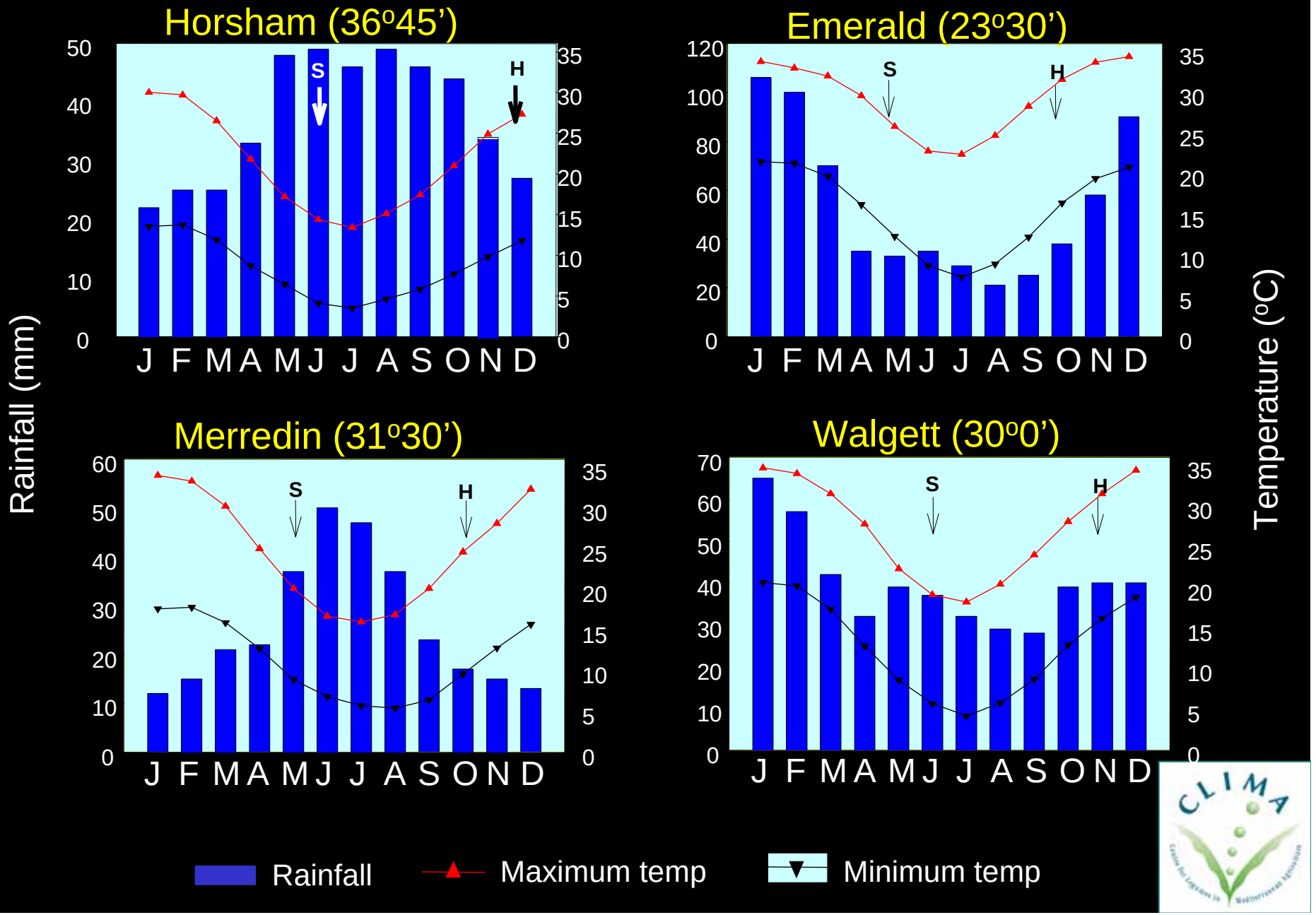
Cool season	Warm Season
Narrow-leafed lupin (*Lupinus angustifolius*)	Mung bean (*Vigna* spp.)
Field pea (*Pisum sativum*)	Navy-culinary bean (*Phaseolus vulgaris*)
Chickpea- desi and kabuli (*Cicer arietinum*)	Adzuki bean (*Vigna angularis*)
Faba bean (*Vicia faba*)	Cow pea (*Vigna ungiculata*)
Lentil-red and green (*Lens culinaris*)	Pigeon pea (*Cajanus cajan*)
Albus lupin (*Lupinus albus*)	Lablab (*Lablab purpureus*)
Vetch (*Vicia* spp.)	Lima bean (*Phaseolus lunatus*)
Yellow-lupin (*Lupinus luteus*)	
Grass pea (*Lathyrus* spp.)	
Narbon bean (*Vicia narbonensis*)	

Adapted from Siddique and Sykes (1997) Aust. J. Exp. Agric.

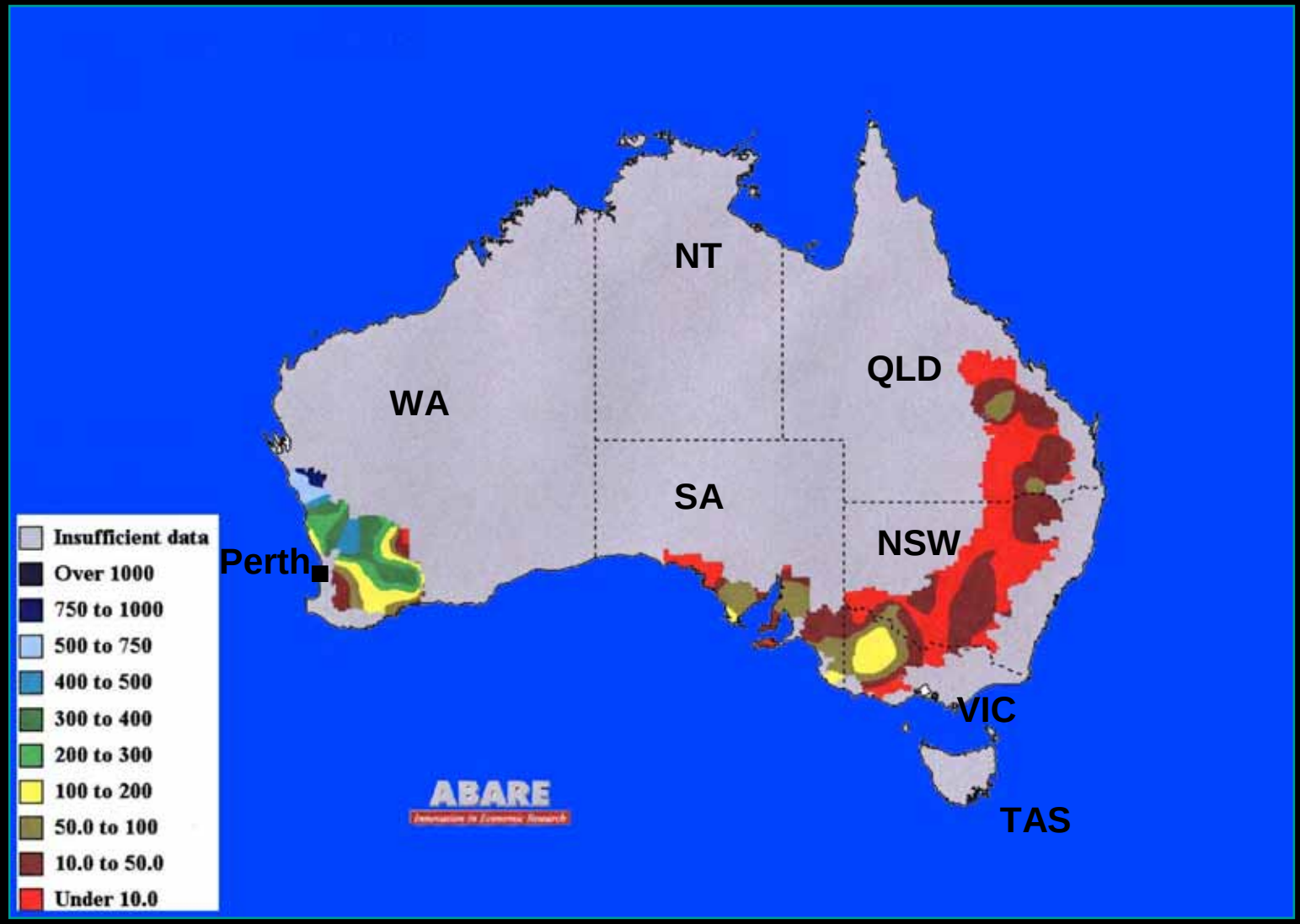
Grain legume growing regions of Australia



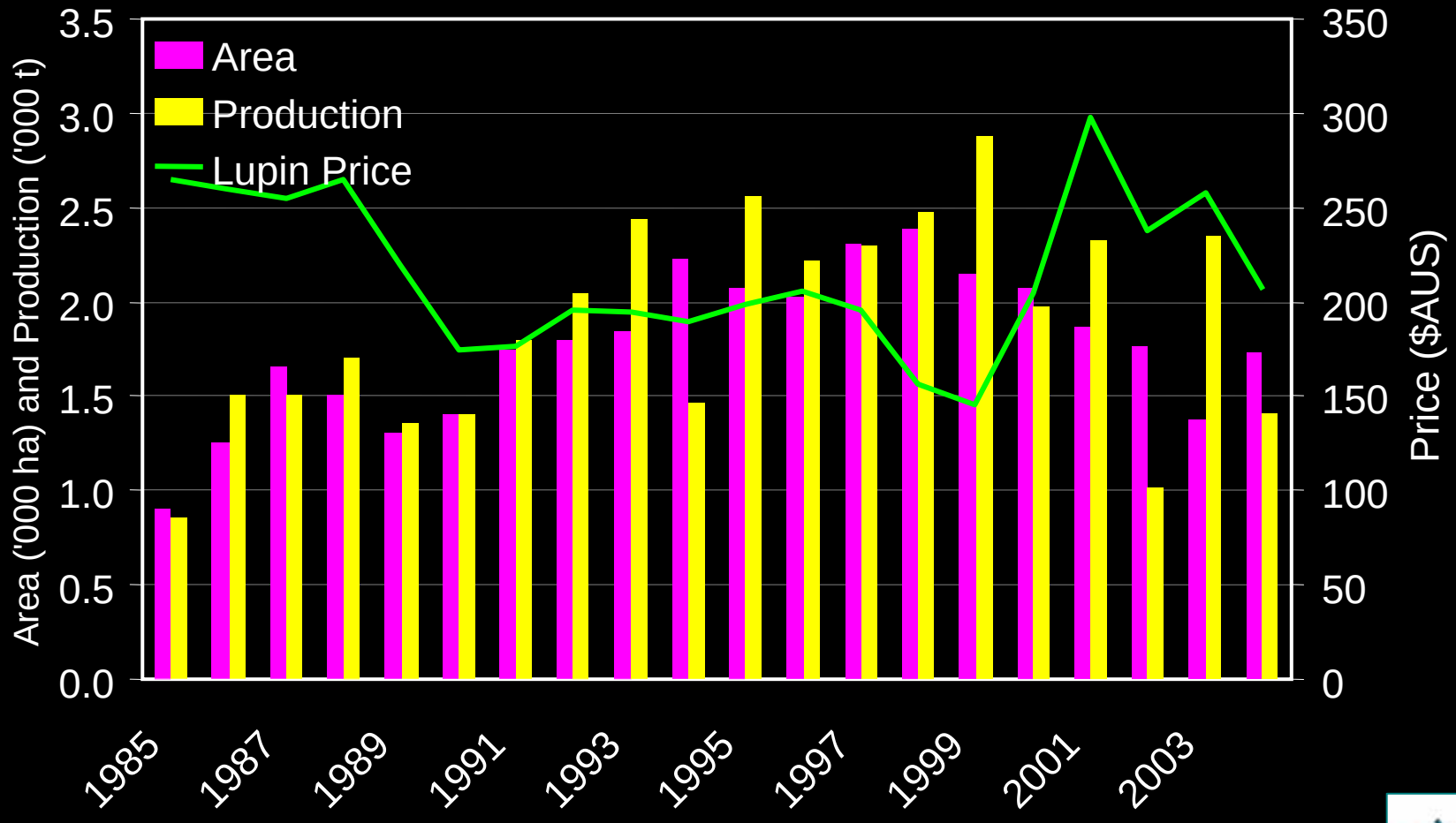
Rainfall & temperature in pulse growing areas of Australia



Average area sown to grain legumes (ha)



Area (million ha) and production (million t) of grain legume crops, and lupin price* ($A) in Australia



*Lupin prices in $A/tonne delivered principal market; averaged across all grades, averages over a calendar year

Australian grain legume production

- Total area in Australia (2004): 1.70 million ha
- Total production (2004): 1.46 million tonnes
- Yield (2004): 0.97 t/ha
- Farmgate value (2003-04): $AUS 800 million (plus $150 million rotational benefits = $950 million)
- Major species: Lupin, field pea, chickpea, faba bean and lentil

Australian cool season grain legume production 2004

Crop species	Area (ha)	Production (t)	Yield (t/ha)
Lupin	633,000	758,000	1.20
Field pea	240,000	311,000	0.97
Faba bean	187,000	210,000	1.08
Chickpea	109,000	115,000	1.10
Lentil	116,000	65,000	0.55
Vetch	235,000	54,000	0.90

Source: Pulse Australia

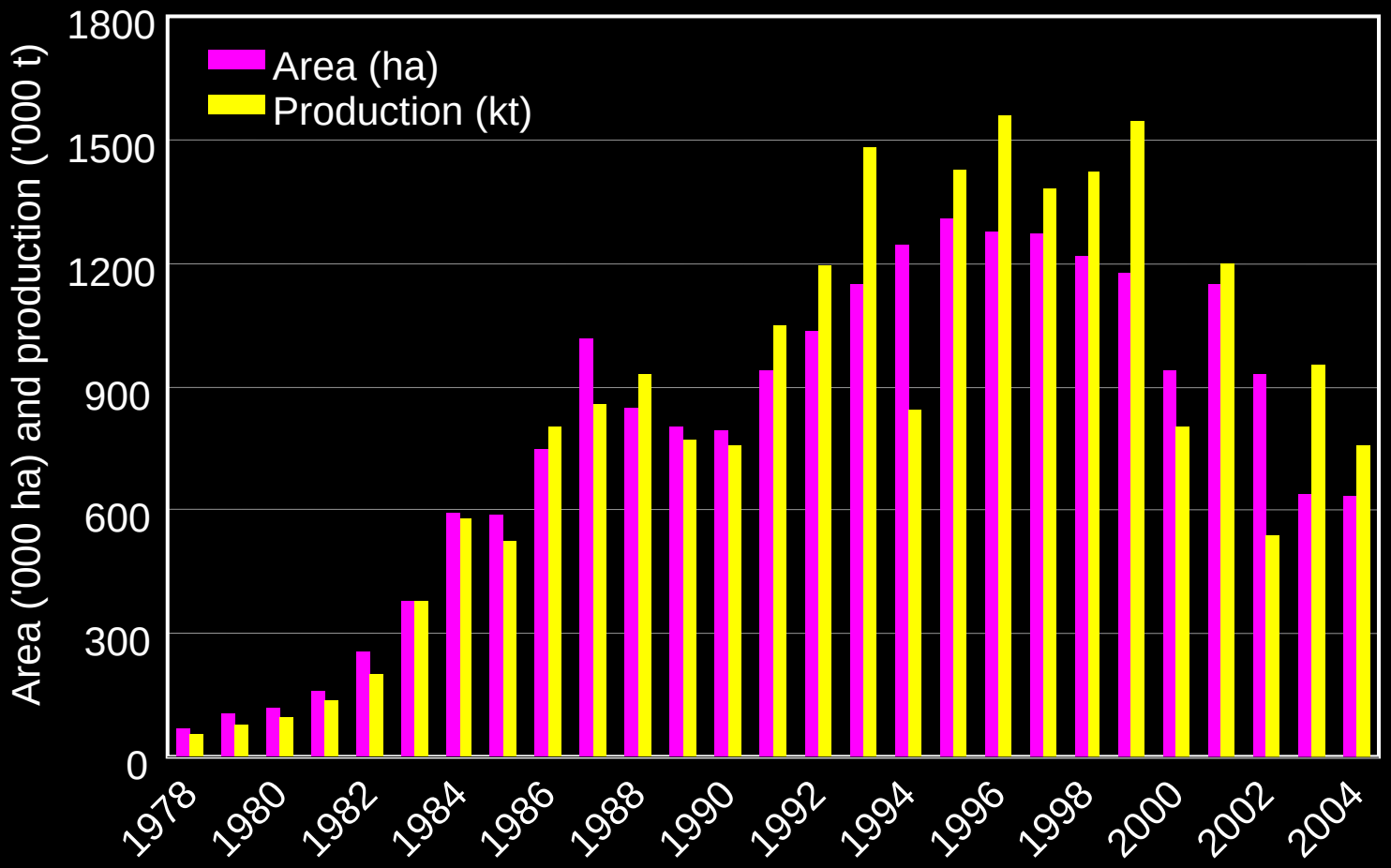
Proportion of grain legumes in the Australian farming system

- Current Australian average is 10%
- Can we increase this to 15 - 20%
- Some innovative farmers are already including a larger proportion of grain legumes in their cropping program

What can we learn from them?

Lupin

Lupin production in Australia

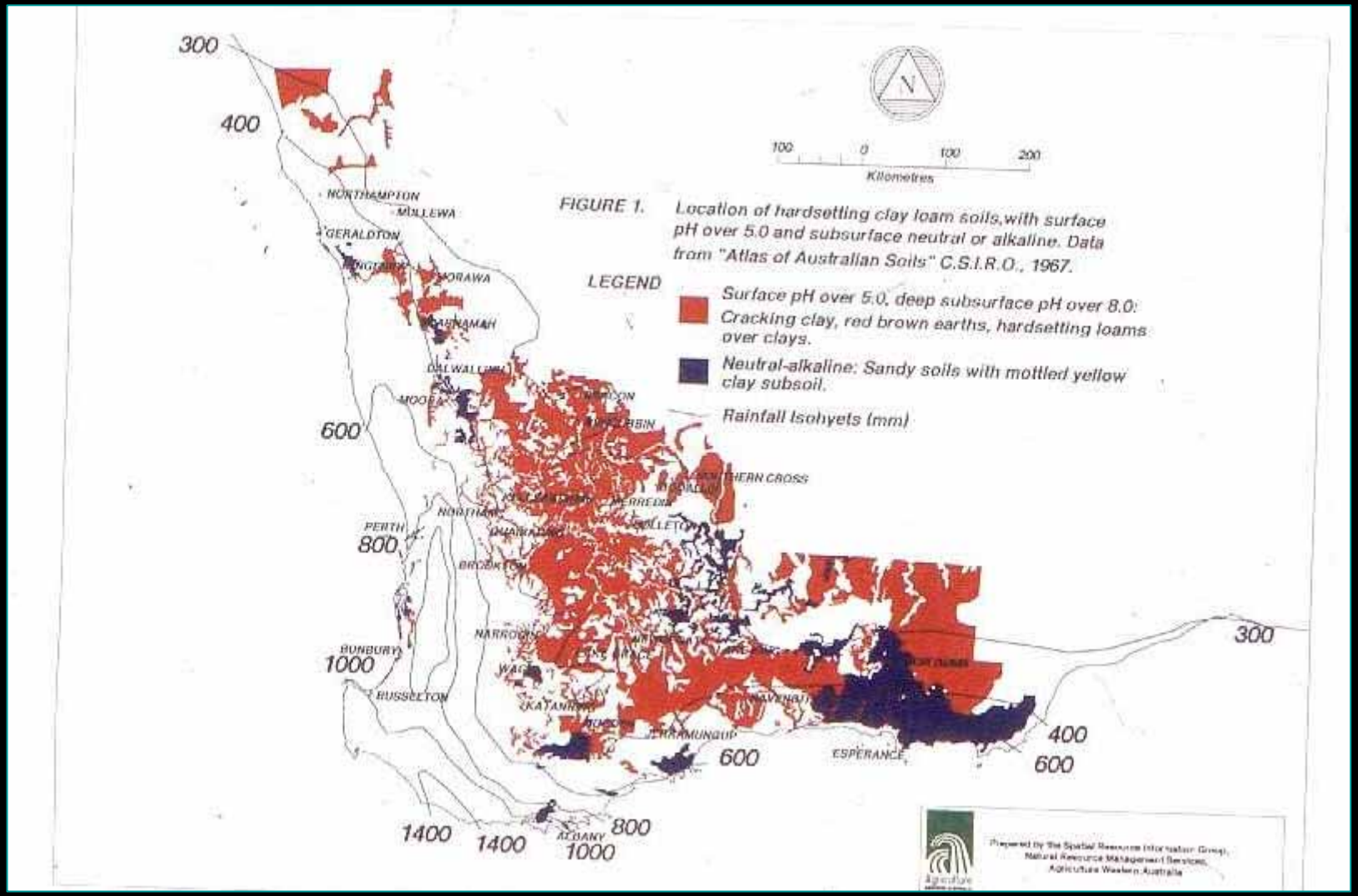


Lupin industry and its benefit

- Narrow-leafed lupin has become the major pulse crop in Australia over the past 20 years with > 75% of production in WA
- Smaller industries in NSW, SA and Vic
- Lupins are mainly adapted to coarse-textured, acidic to neutral soils common in WA
- Benefits include improved soil nitrogen, organic matter content, better weed management, reduced level of disease, and increased diversity of cash income

Major constraints to lupin production

- Low price of grain relative to canola and other grain legumes
- Variable and low yields in many regional environments
- Fungal diseases (anthracnose and root rot)
- Aphid damage and virus infection
- Herbicide resistant weeds in lupin-cereal rotation



Soil types suitable for pulses

Aims

- To study the adaptation of a wide range of cool season grain legumes (pulses) to low-rainfall Mediterranean-type environments of southern Australia
- To develop and extend profitable, production packages to growers
- To develop new pulse varieties for specific regional environments

2. Pulse species and adaptation

Species

Field pea (*Pisum sativum)*
Faba bean (*Vicia faba*)
Common vetch (*Vicia sativa*)
Lathyrus cicera
Lathyrus sativus
Lathyrus ochrus
Narbon bean (*Vicia narbonensis*)
Desi chickpea (*Cicer arietinum*)
Lentil (*Lens culinaris*)
Albus lupin (*Lupinus albus*)
Bitter vetch (*Vicia ervilia*)
Kabuli chickpea (*Cicer arietinum*)

Experimental sites in south-western Australia

No of sites: 46

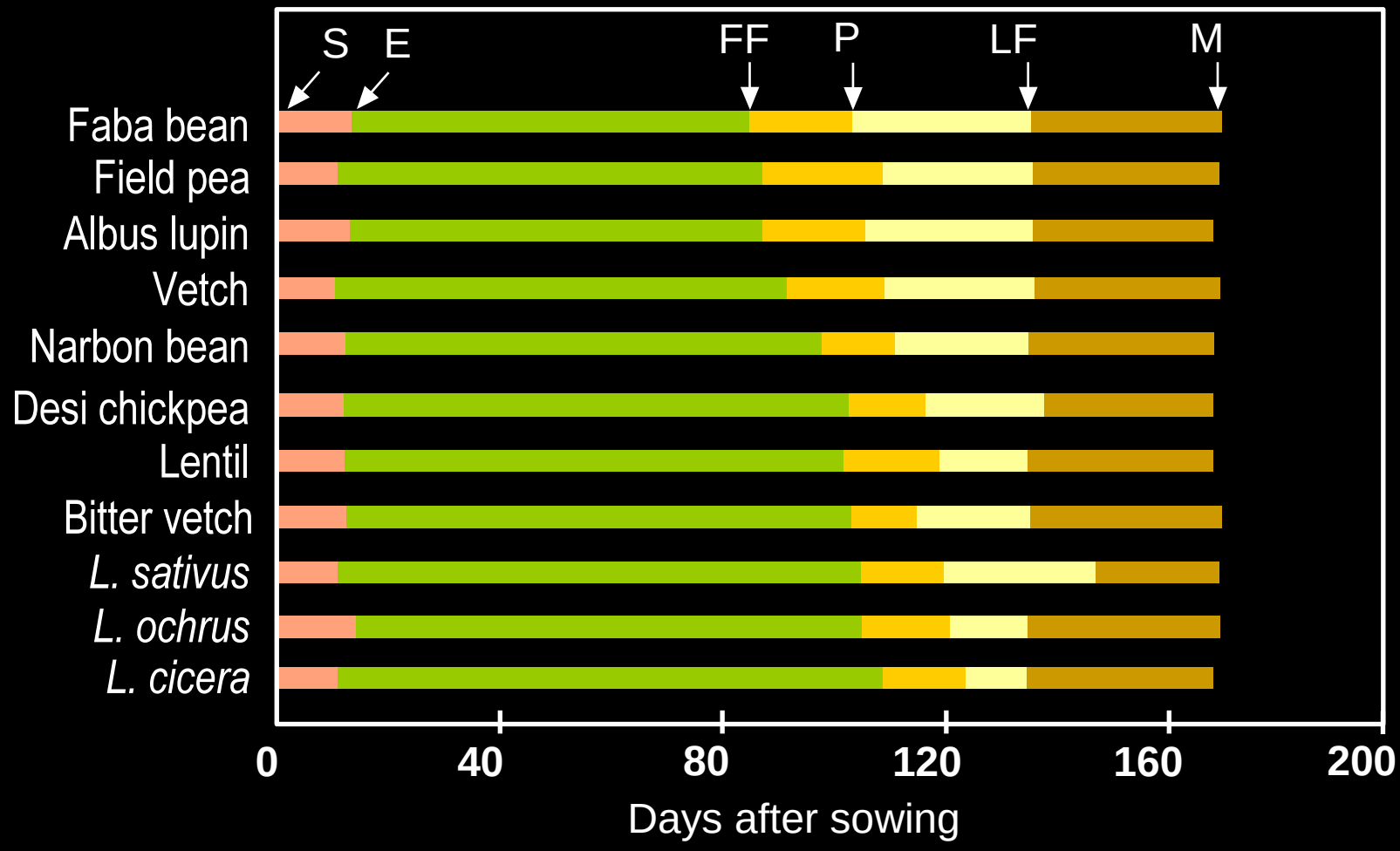
years: 3

Pulse species x environment interaction

Fixed effects	Wald statistic	Degrees of freedom	P value
Species	72.2	11	>0.001
pH (0-10 cm)	118.2	1	>0.001
Species. pH (0-10 cm)	31.8	11	>0.001
pH (30-40 cm)	13.5	1	>0.001
Rainfall	19.3	1	>0.001
Year	5.5	2	0.064
Site	331.9	23	>0.001

Siddique *et al.* (1999) Aust. J. of Agric. Res.

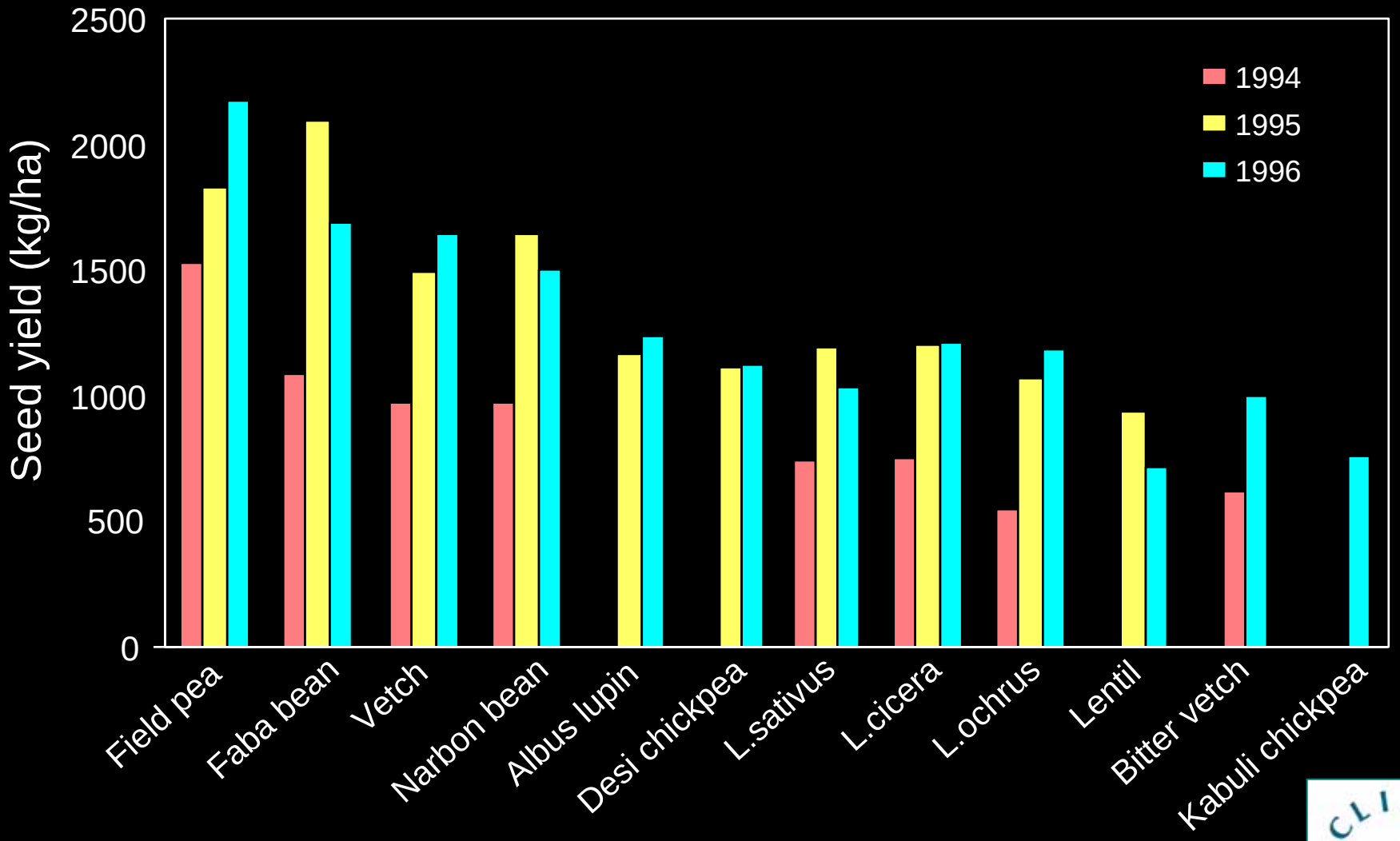
Phenology at Merredin, 1995



Days from sowing (S) to emergence (E), 50% first flower (FF), 50% first pod (P), last flower (LF) and 95% maturity (M)

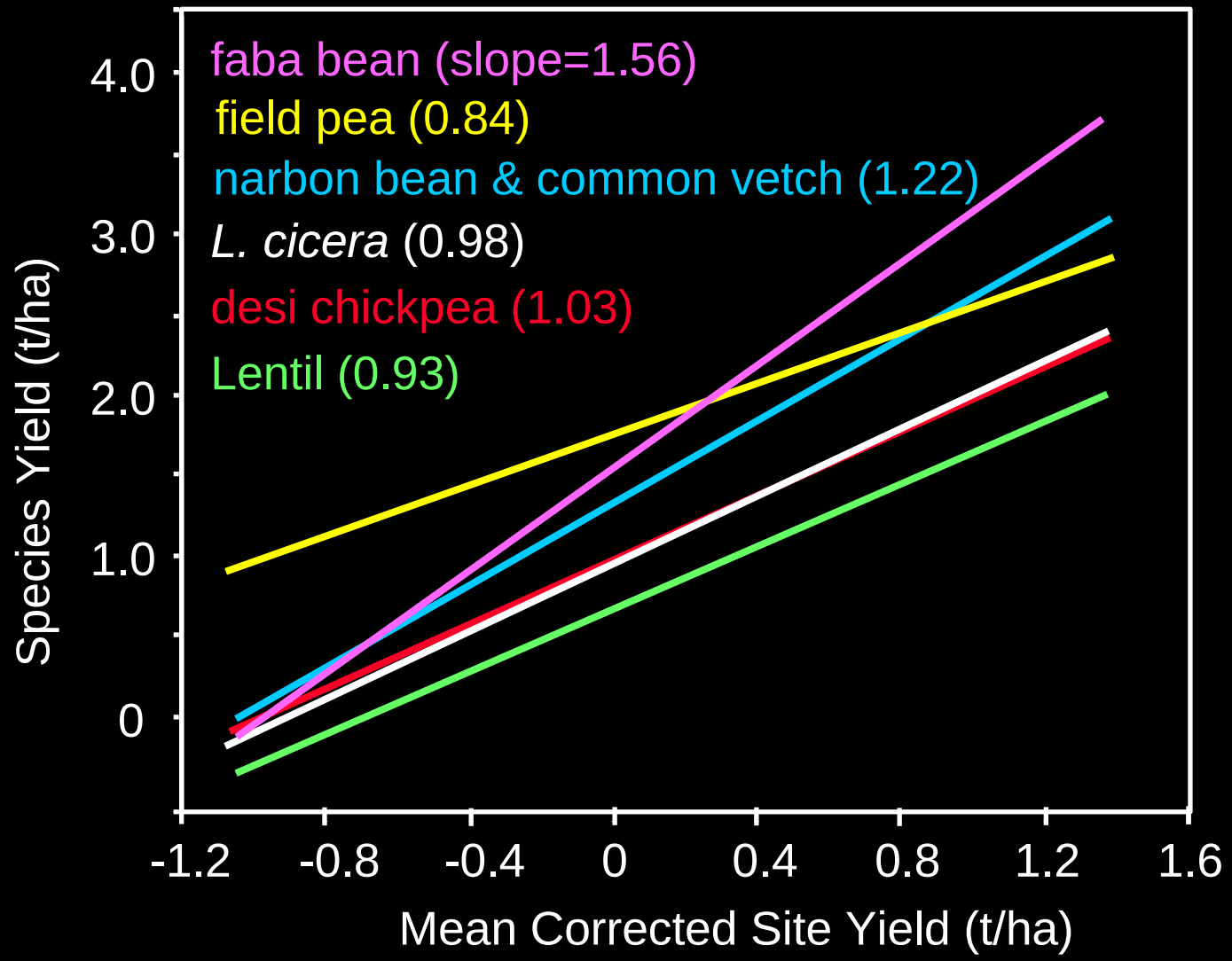
Siddique *et al.* (1999) Aust. J. of Agric. Res.

Mean seed yields of pulse species in WA



Siddique *et al.* (1999) Aust. J. of Agric. Res.

Pulse species x environment interaction



Siddique *et al.* (1999) Aust. J. of Agric. Res.

Field pea crop

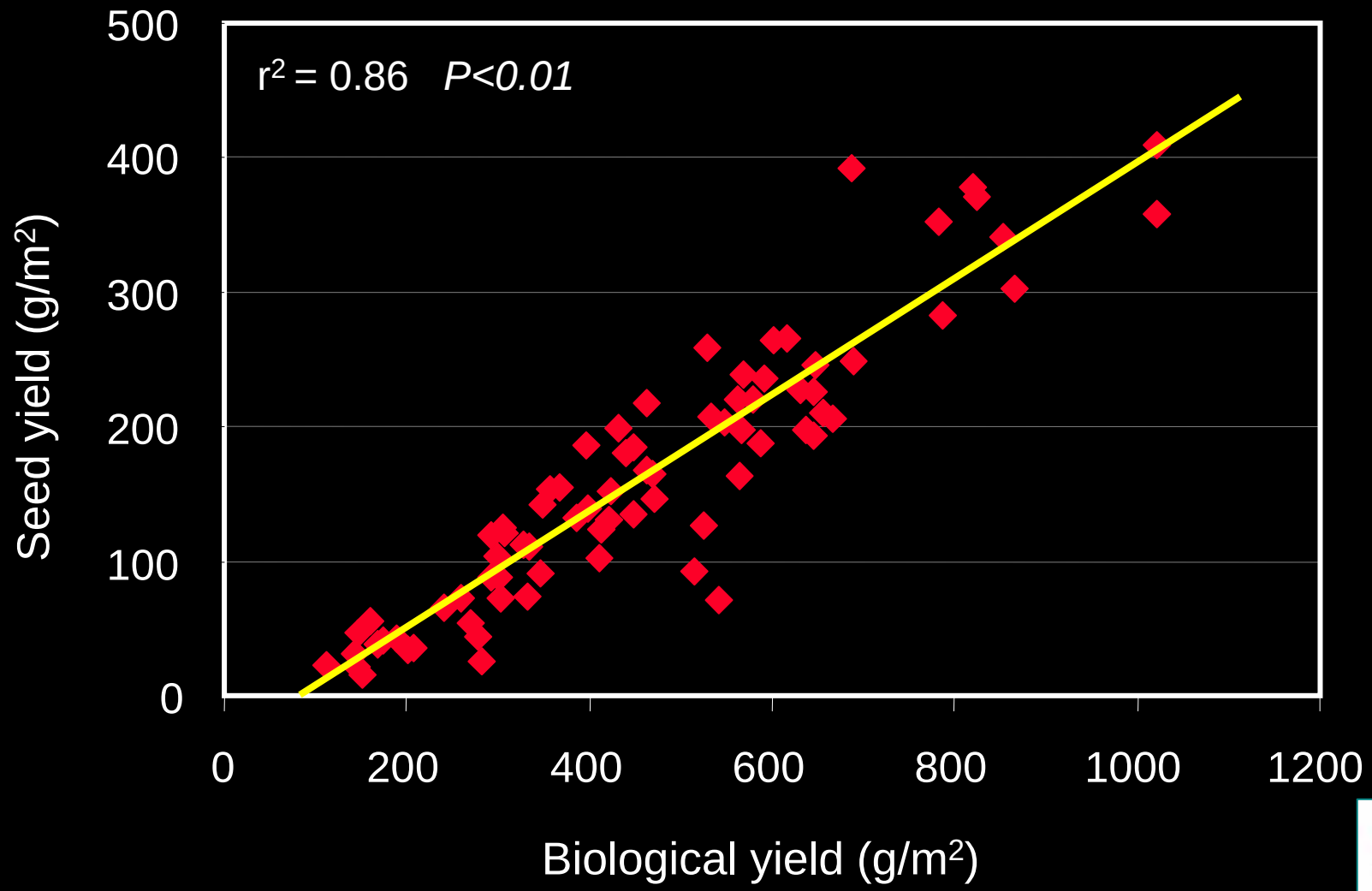
Faba bean crop

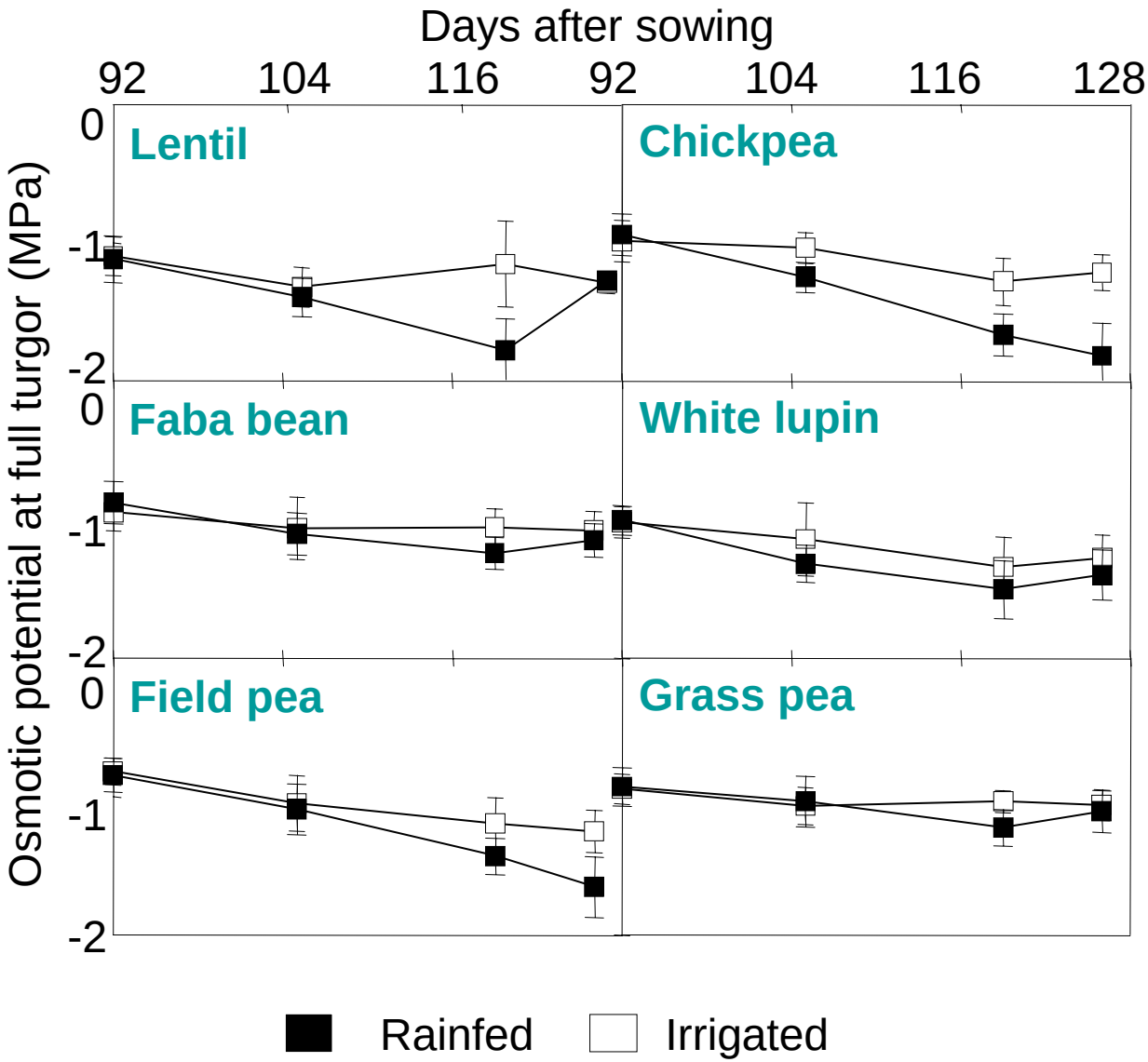
Faba bean & soil types:

High pH & heavy textured soil

Low pH & coarse textured soil

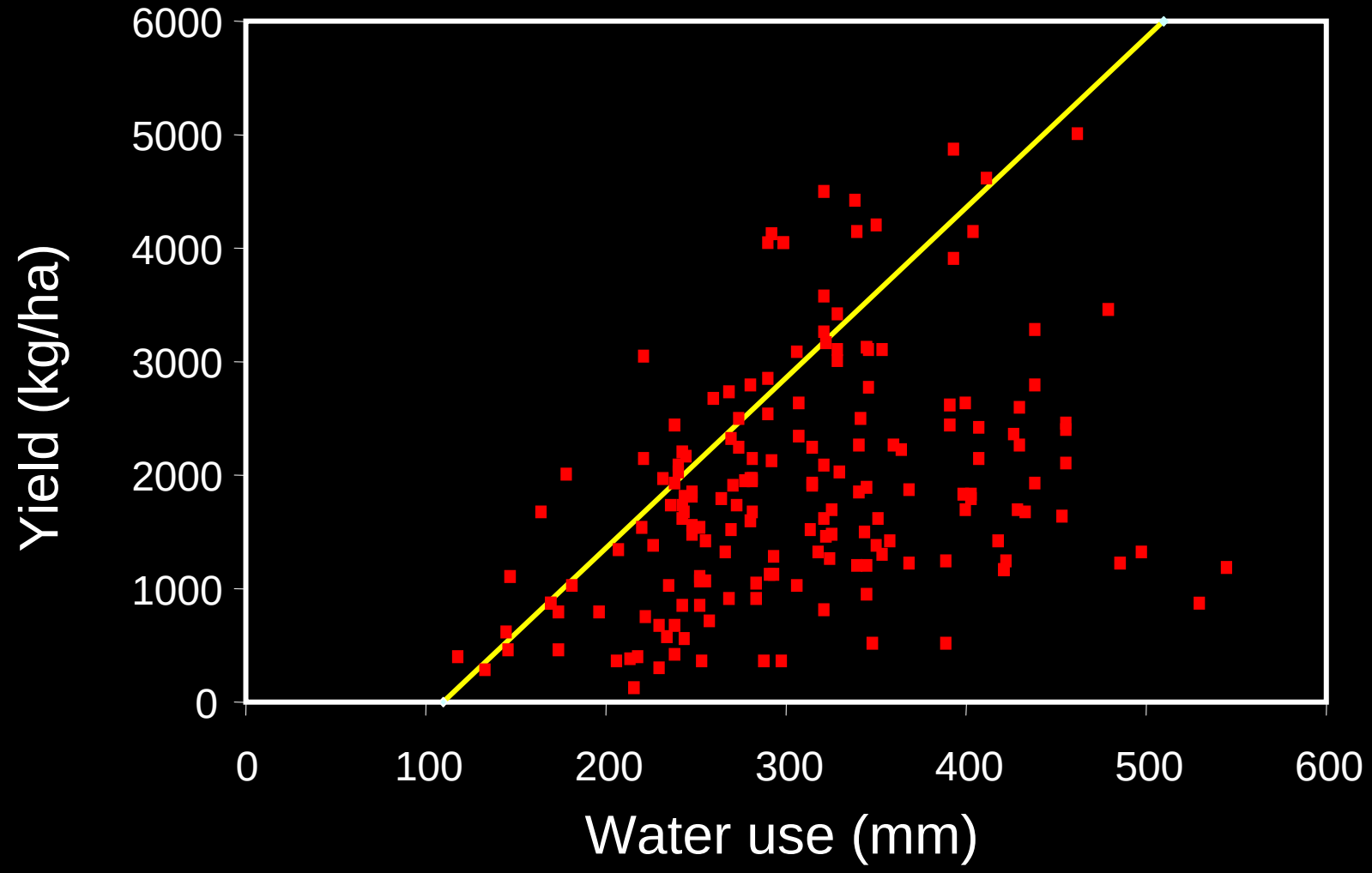
Correlation between biological and seed yield





Leport et al. *et al.* 1998, Europ J. of Agron.

Water use efficiency of faba bean



Potential yield = [estimated crop water use (mm) - 110 mm] x 15 kg/ha/mm

Adapted from Siddique *et al.* (2001) Europ. J. of Agron.

Water use & water use efficiency* of pulse species in WA

Species	Et (mm)	Eta/Etpa	WUEdm (kg ha^{-1} mm $^{-1}$)	WUEsy (kg ha^{-1} mm $^{-1}$)
Faba bean	197	0.90	24	11
Field pea	199	1.09	26	10
Chickpea	206	1.54	16	6
Lentil	202	0.87	13	4

Et: total water use
Eta/Etpa: ratio of pre- to post-anthesis water use
WUEdm: water use efficiency for dry matter production
WUEsy: water use efficiency for seed yield

* Mean of two sites over two years

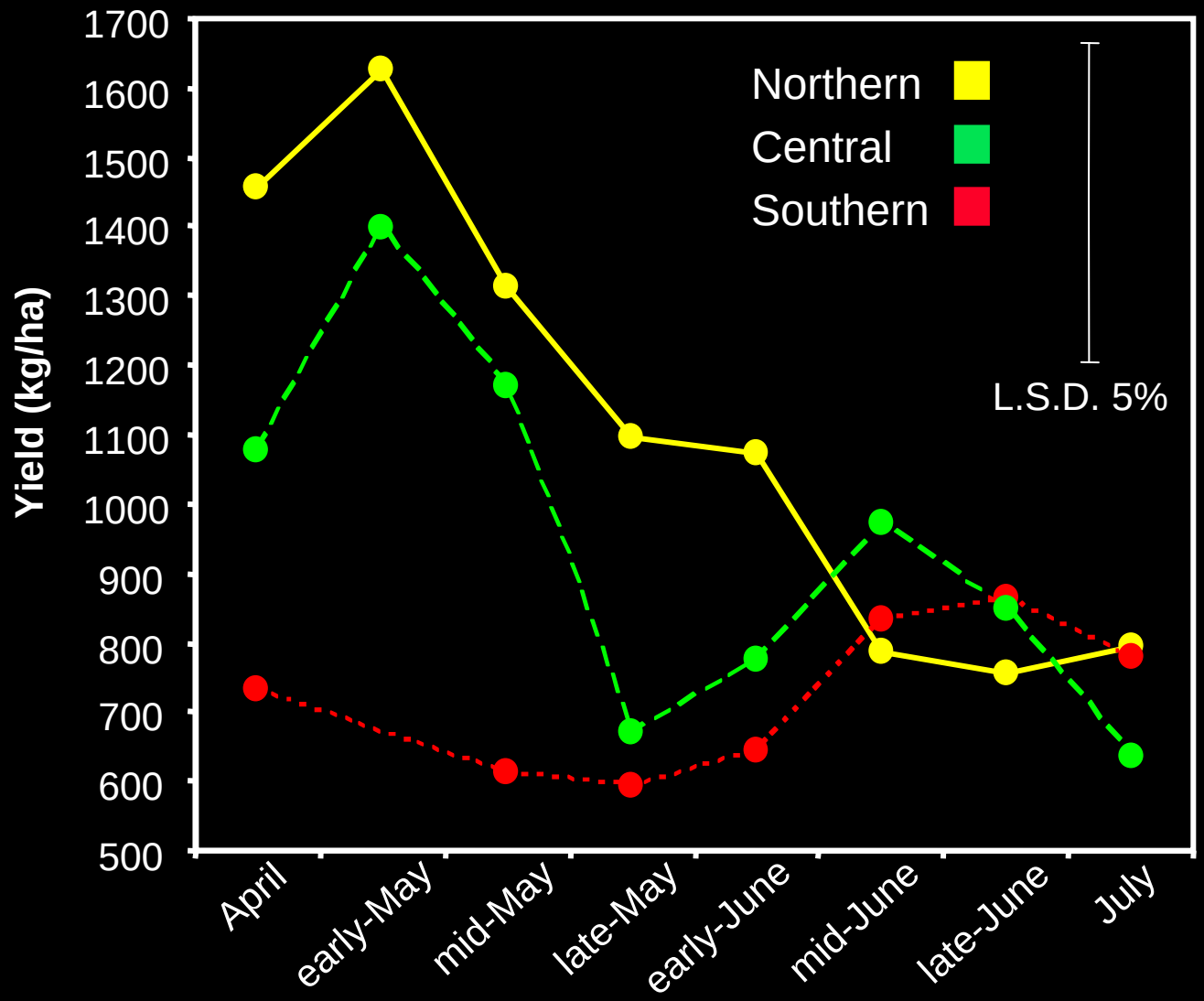
Adapted from Siddique *et al.* (2001) Europ. J. of Agron.

3. Production Agronomy

Optimum time of sowing for cool season grain legumes in WA

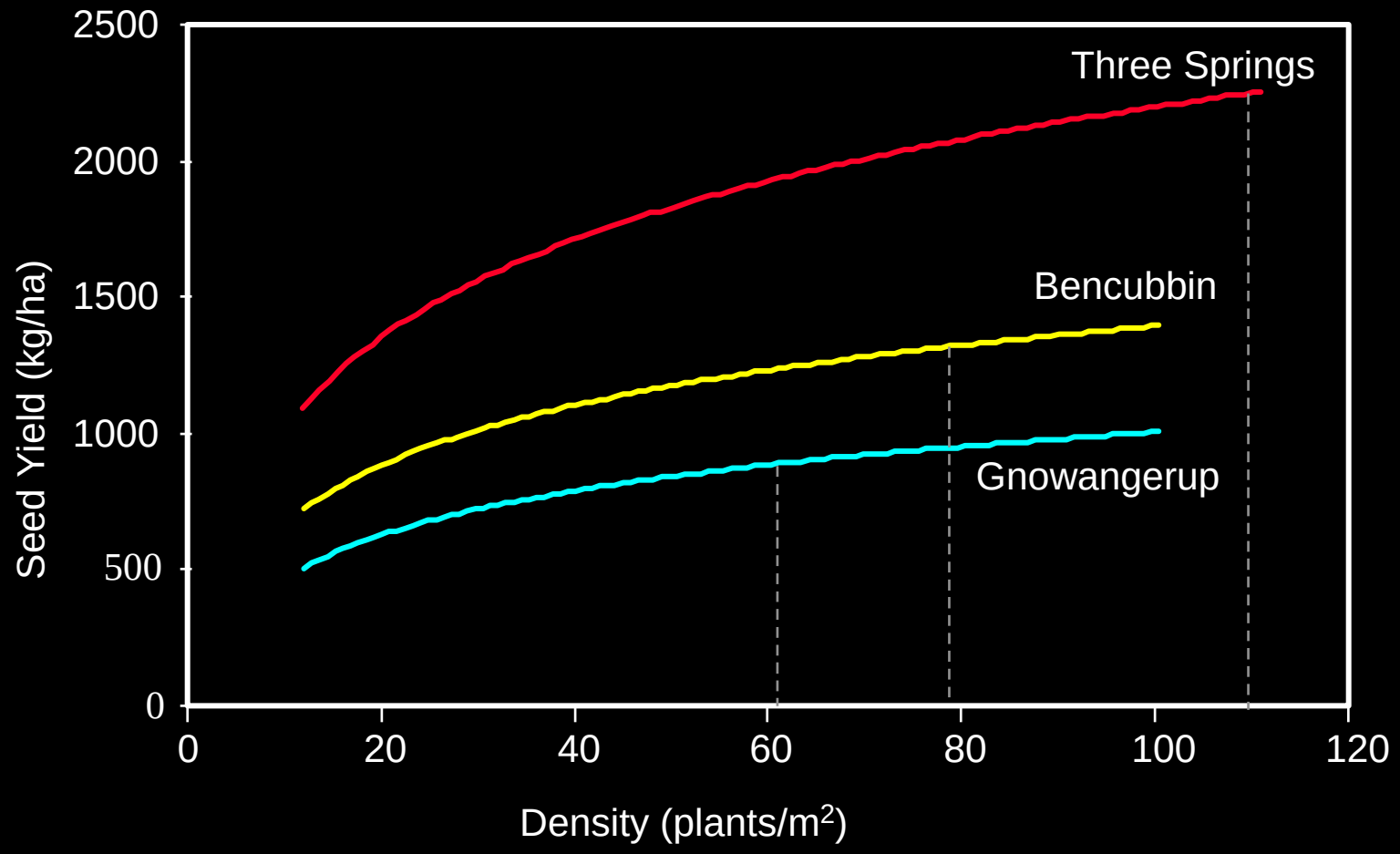
Species	Optimum sowing times	Reference
Field pea	Early May – late June	Pritchard, 1993
Chickpea	Mid May – late June	Regan *et al.*, 2005
Lentil	Early May – mid June	Siddique *et al.*, 1998
Faba bean	Late April – early June	Loss *et al.*, 1997
Lathyrus	Early April – late June	Hanbury *et al.*, (unpublished)
Vetch	Early May – mid June	Seymour *et al.*, 2000

Yield response of chickpea to time of sowing in Western Australia (1994 to 1998)



Regan *et al*. (2005) Aust. J. Expt. Agric

The relationship between plant density & seed yield of desi chickpea at three typical sites in WA

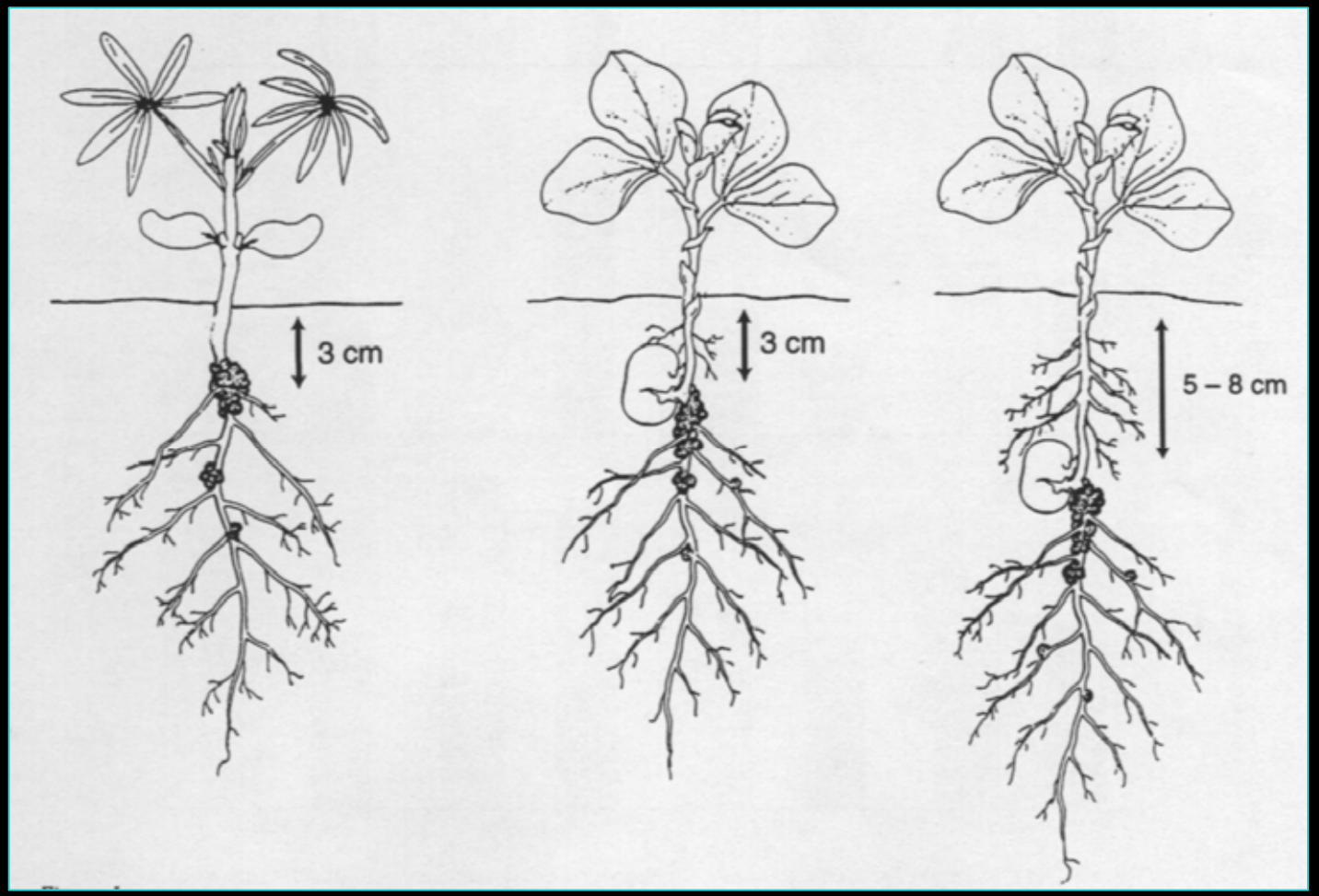


Dotted lines indicate the estimated optimum plant density

Jettner *et al.* (1999) Aust. J. Agric. Res.

Epigeal emergence

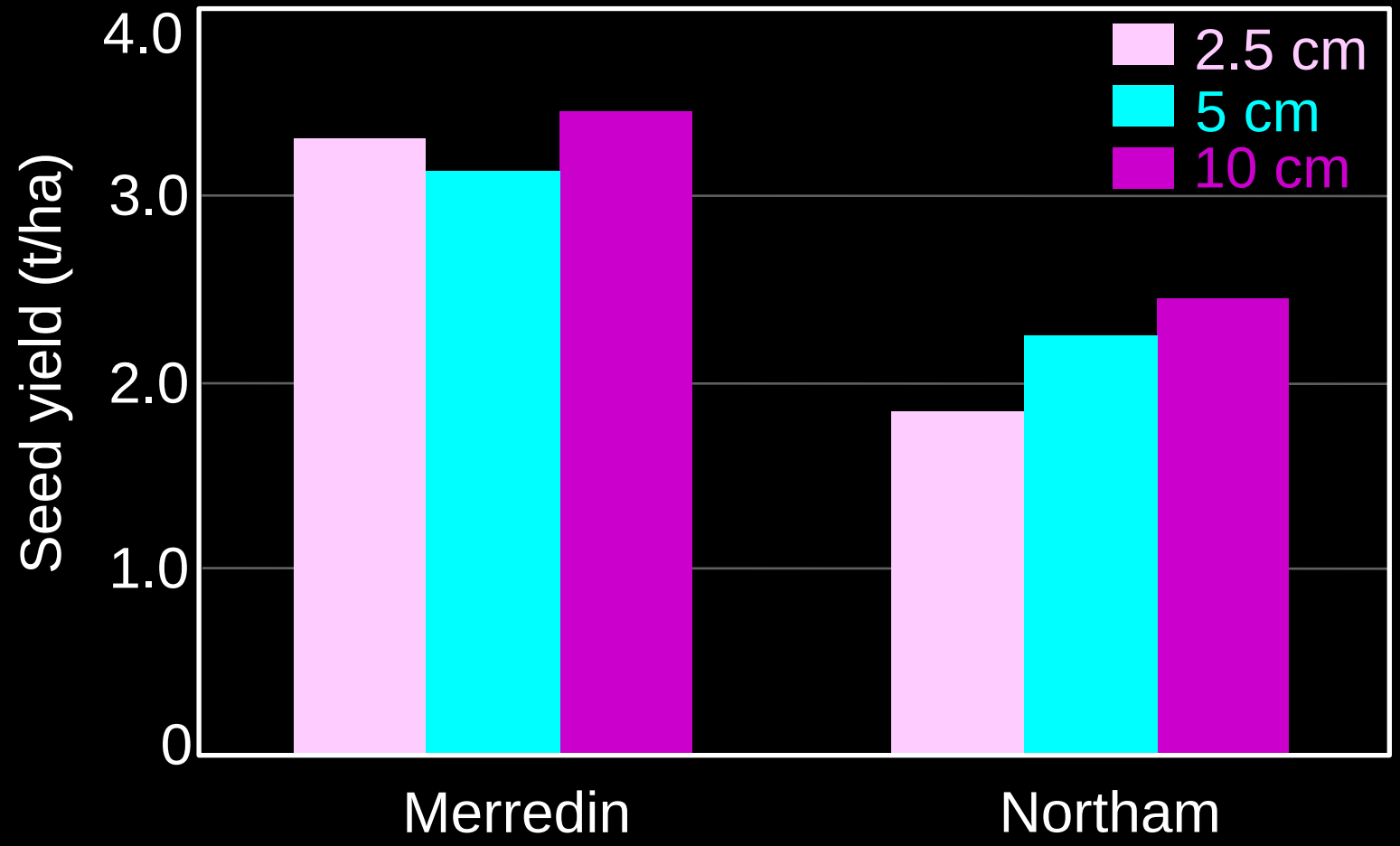
Hypogeal emergence



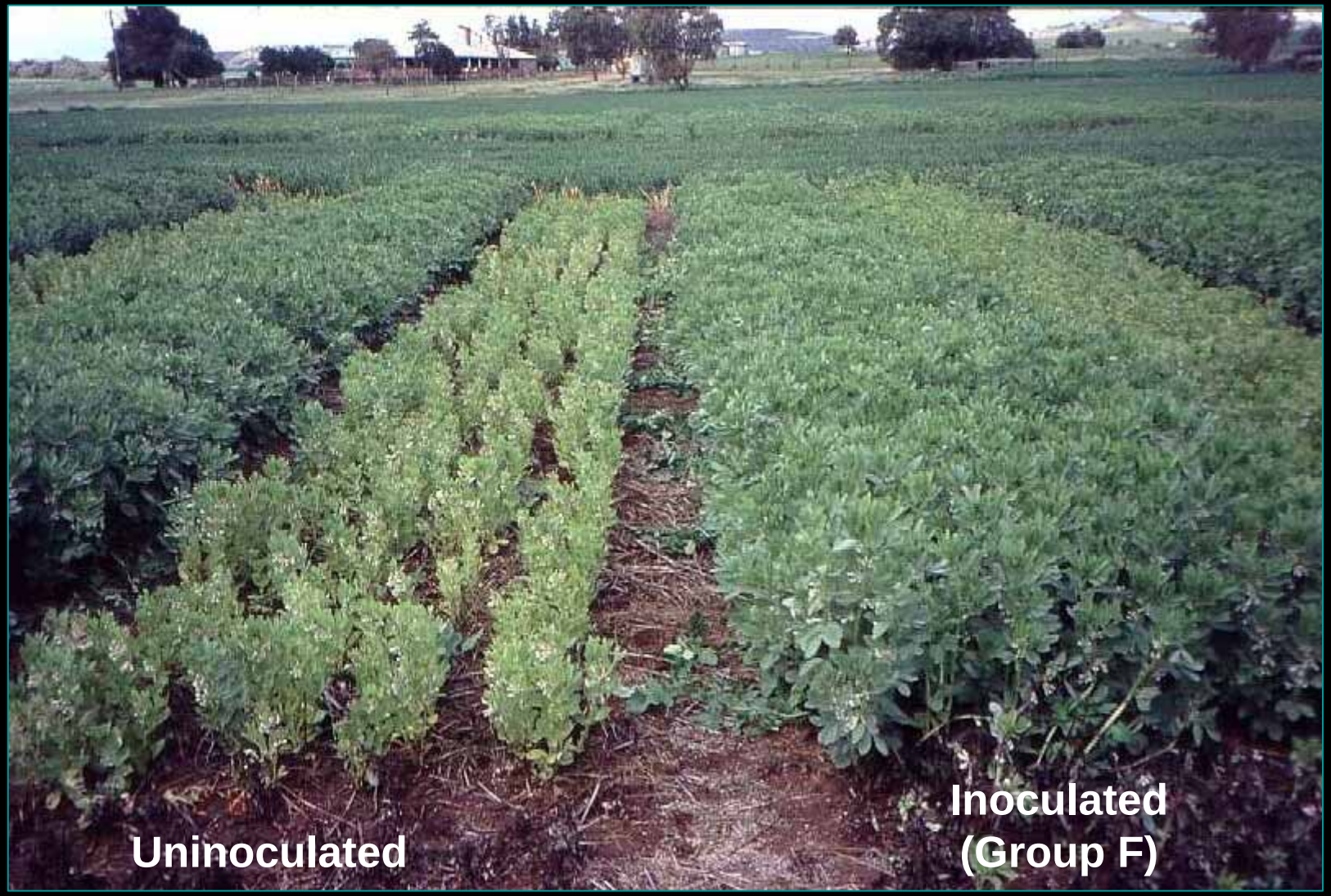
Lupin

Faba bean

Effect of sowing depth on seed yield of faba bean,1996



Siddique and Loss, 1999 J. Agron. and Crop Sci.



Faba bean, Chapman Valley, WA

4. Genetic Improvement

Kimberley large chickpea

Cool season grain legume varieties developed and released in WA

Species/ varieties	Year of release	Species/ varieties	Year of release
Field Pea		***Chickpea***	
Magnet	1997	Sona (D)	1997
King	1997	Heera (D)	1997
Cooke	1999	Moti (D)	2003
Helena	1999	Rupali (D)	2004
Dunwa	2001	Sonali (D)	2004
		Kimberley Large (K)	2004
		Almaz (K)	2005
		Nafice (K)	2005
Lentil		***Lathyrus***	
Cassab	1998	Chalus	1998
Cumra	1998	Ceora	2005

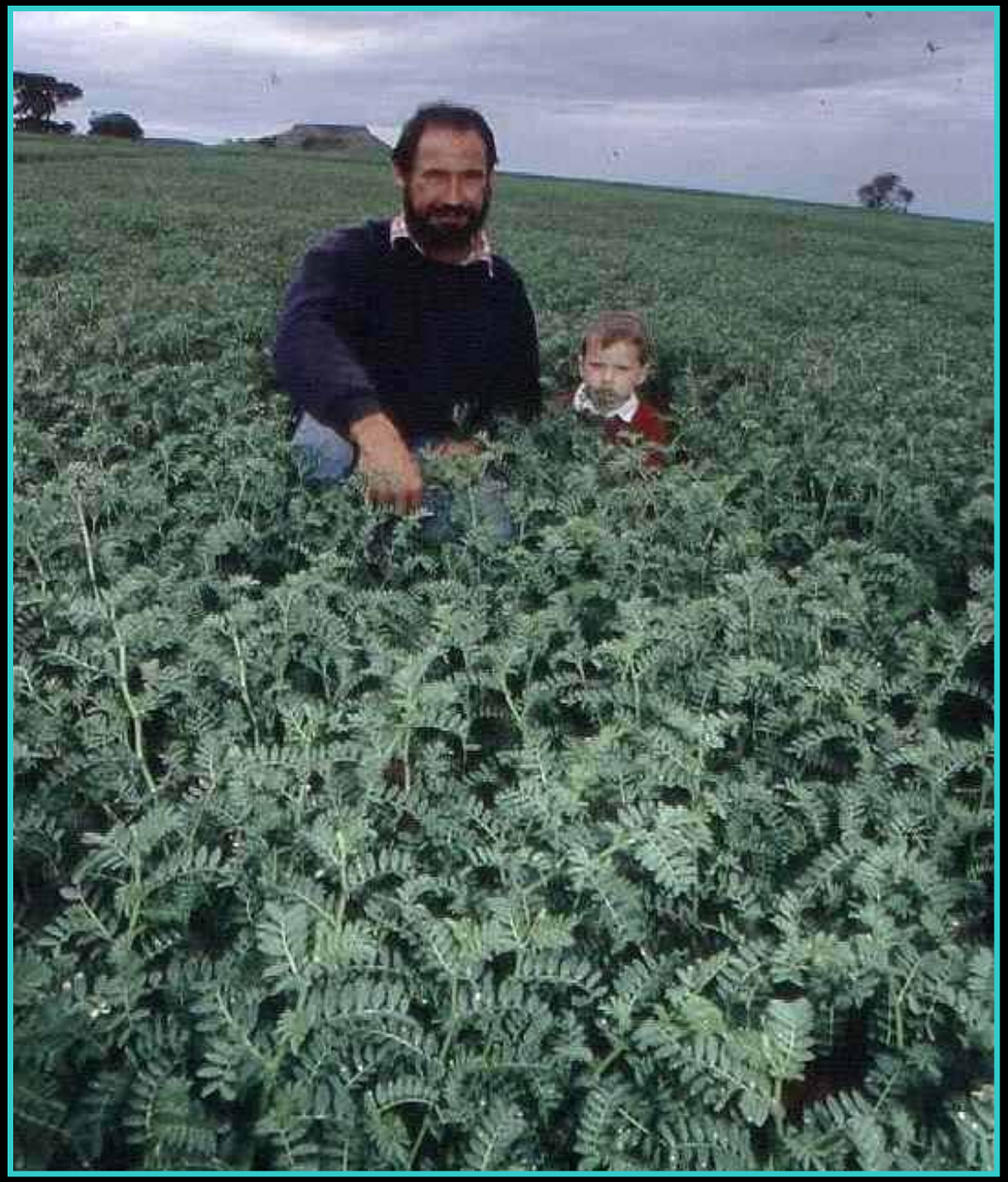
CEORA

(Tested as Lathyrus 20B)

Australia's first grass pea *(Lathyrus sativus)* cultivar

Ceora

- Low-input, low-cost, grain/forage legume
- Potential area in Australia 150,000 - 300,000 ha
- Tolerant to a wide range of herbicides, waterlogging and drought stress and serious diseases
- Best adapted to medium to heavy textured soils with 300-650 mm annual rainfall



Rapid adoption of desi chickpea (Sona and Heera) by farmers as a cash crop occurred in the mid to late 1990's

International Partnership – Aschochyta resistant kabuli chickpea development (1998 - 2005)

Two new ascochyta resistant, high yielding and high quality kabuli chickpea varieties for Australia

NAFICE A (tested as FLIP97-503-CLIMAS)
ALMAZ A (tested as FLIP97-530-CLIMAS)

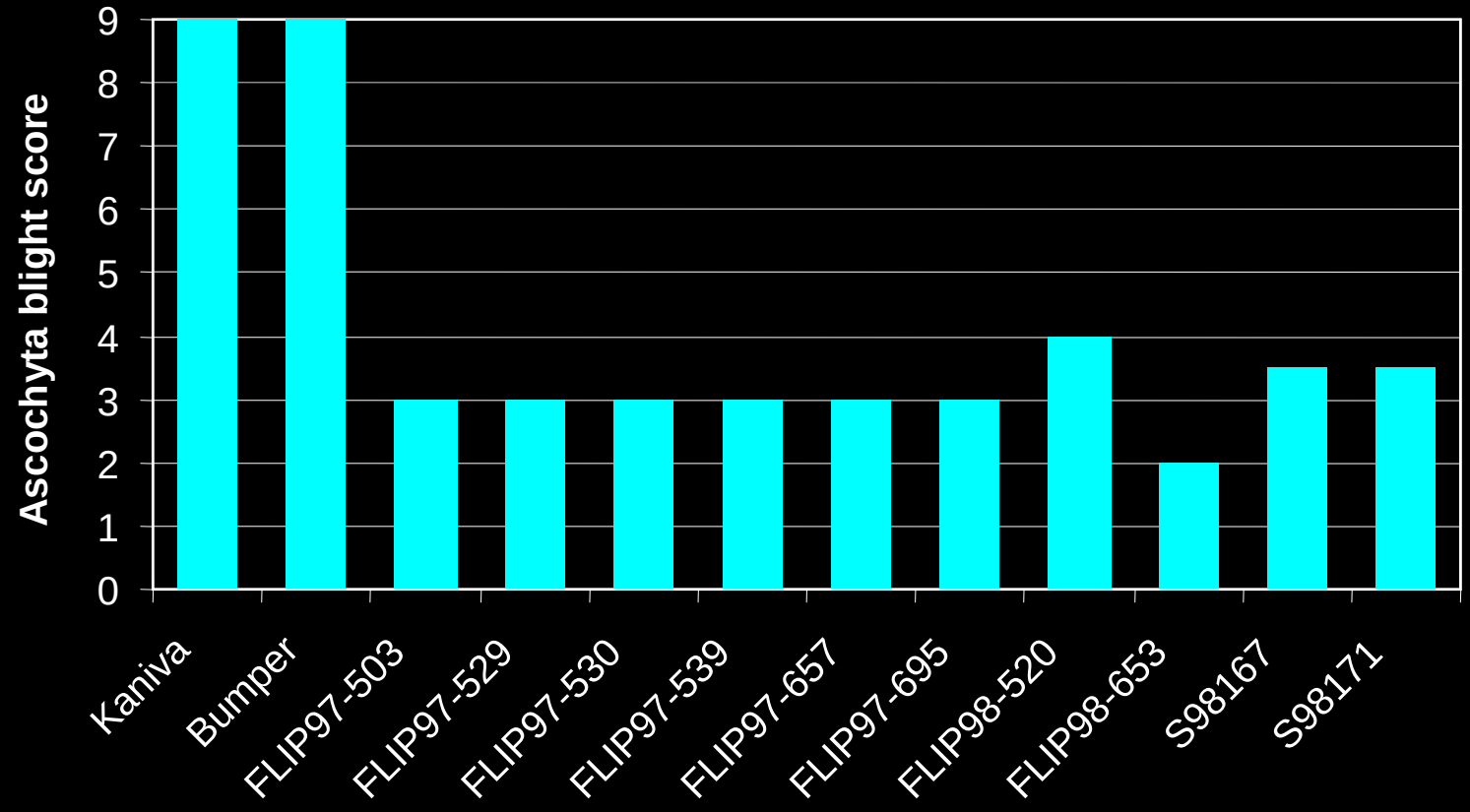
CLIMA

COUNCIL OF GRAIN GROWER ORGANISATIONS LTD
COGGO

GRDC
Grains Research & Development Corporation

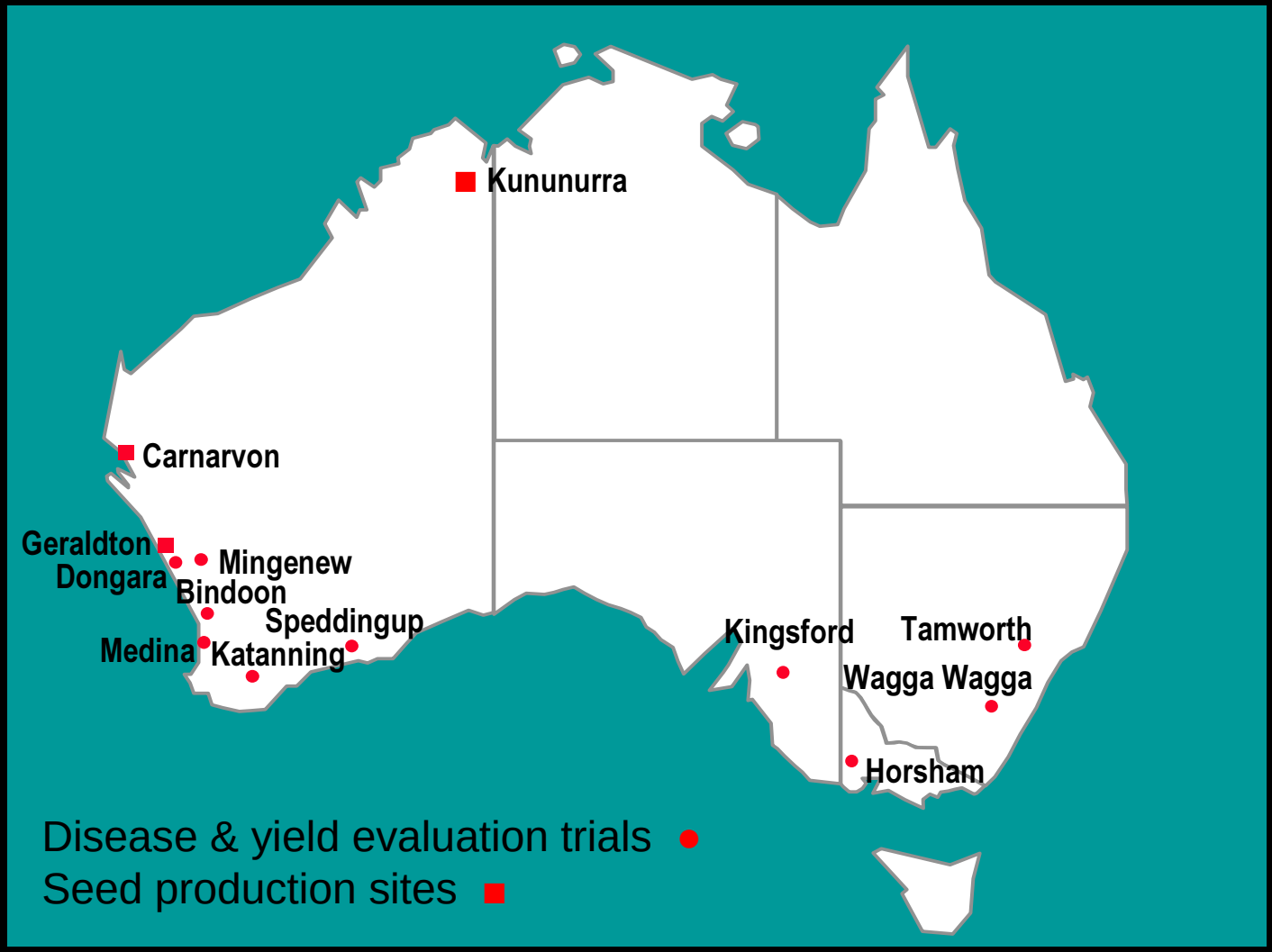
Ascochyta ratings[A] Turkey

(measured at flowering in Menemen, 1998 to 2000)



[A]Disease score where 0 = no disease to 9 = dead

Location of sites for evaluation & seed production of kabuli chickpea crossbred lines



Ascochyta blight disease score
(field & disease nurseries in WA, NSW, Vic & SA, 1999 & 2004)

Variety	Score[A]
Almaz A	3.0
Nafice A	3.5
Kaniva	8.0

[A] Mean disease score (0-9 scale; where 0= no disease and 9 = dead)

Yield

Nafice A and Almaz A have produced greater yield than Kaniva across 15 trials in southern Australia during 2002-2004.

Yield expressed as % Kaniva in trials (WA, Vic, NSW and SA 2002-2004)

(Ascochyta blight absent in 2002. Varying levels of disease in trials 2003 and 2004)

Variety	2002	2003	2004	Overall
	(1)[A]	(8)	(6)	(15)
Nafice A	100	125	108	116
Almaz A	105	151	128	138
Kaniva yield (kg/ha)	1188	932	1072	856

[A] Number of trials

Grain Quality

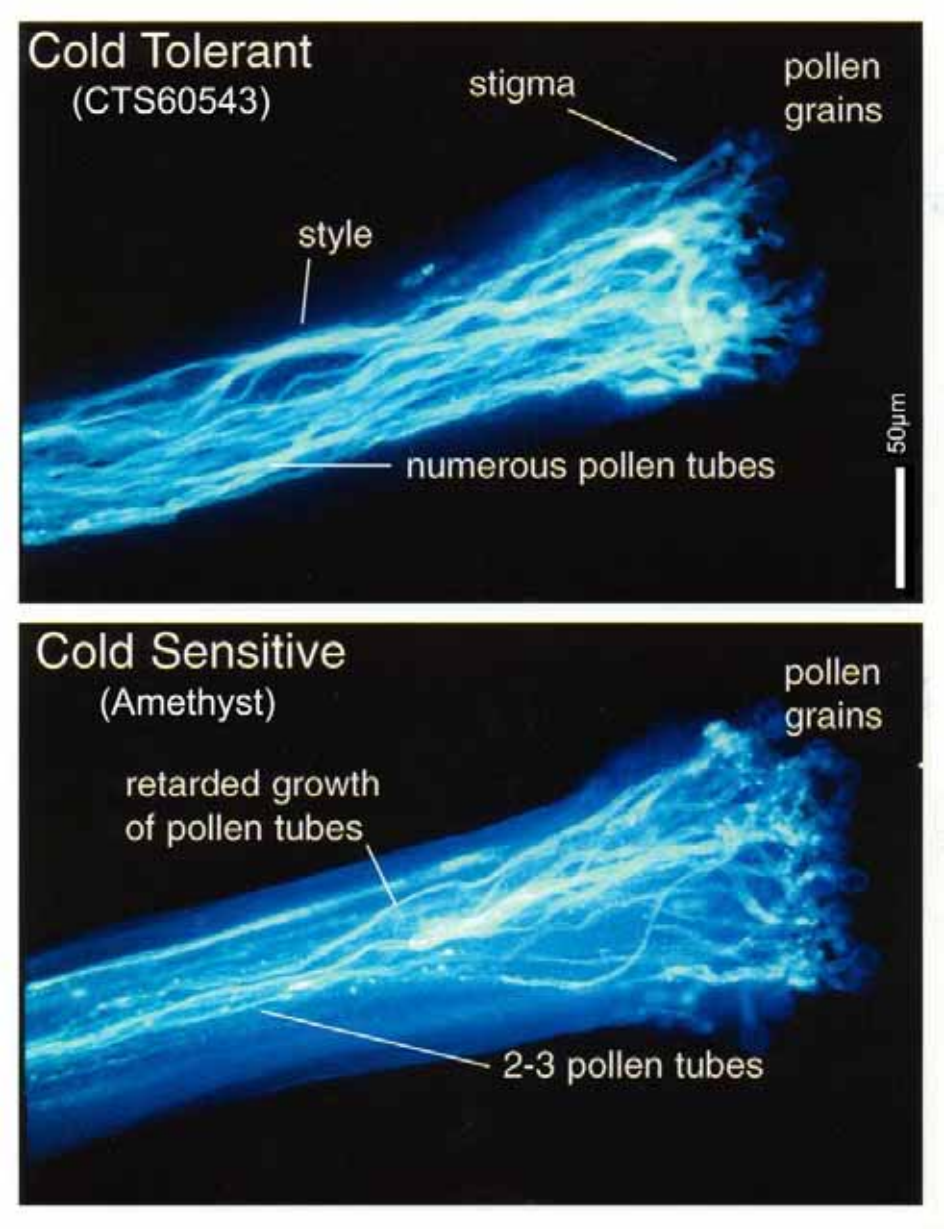
- Produce seeds larger than Kaniva
- Seed coats attractive beige colour similar to Kaniva
- Similar cooking quality to Kaniva

Variety	Mean seed weight		Proportion of seed (%)			
	% Kaniva	mg/seed	**> 9 mm**	**8-9 mm**	**7-8 mm**	**< 7 mm**
Nafice A	120	40	52	34	11	3
Almaz A	117	39	38	43	15	4
Kaniva	100	34	24	46	23	7

[A] Mean of 7 trials between 2002 and 2004.

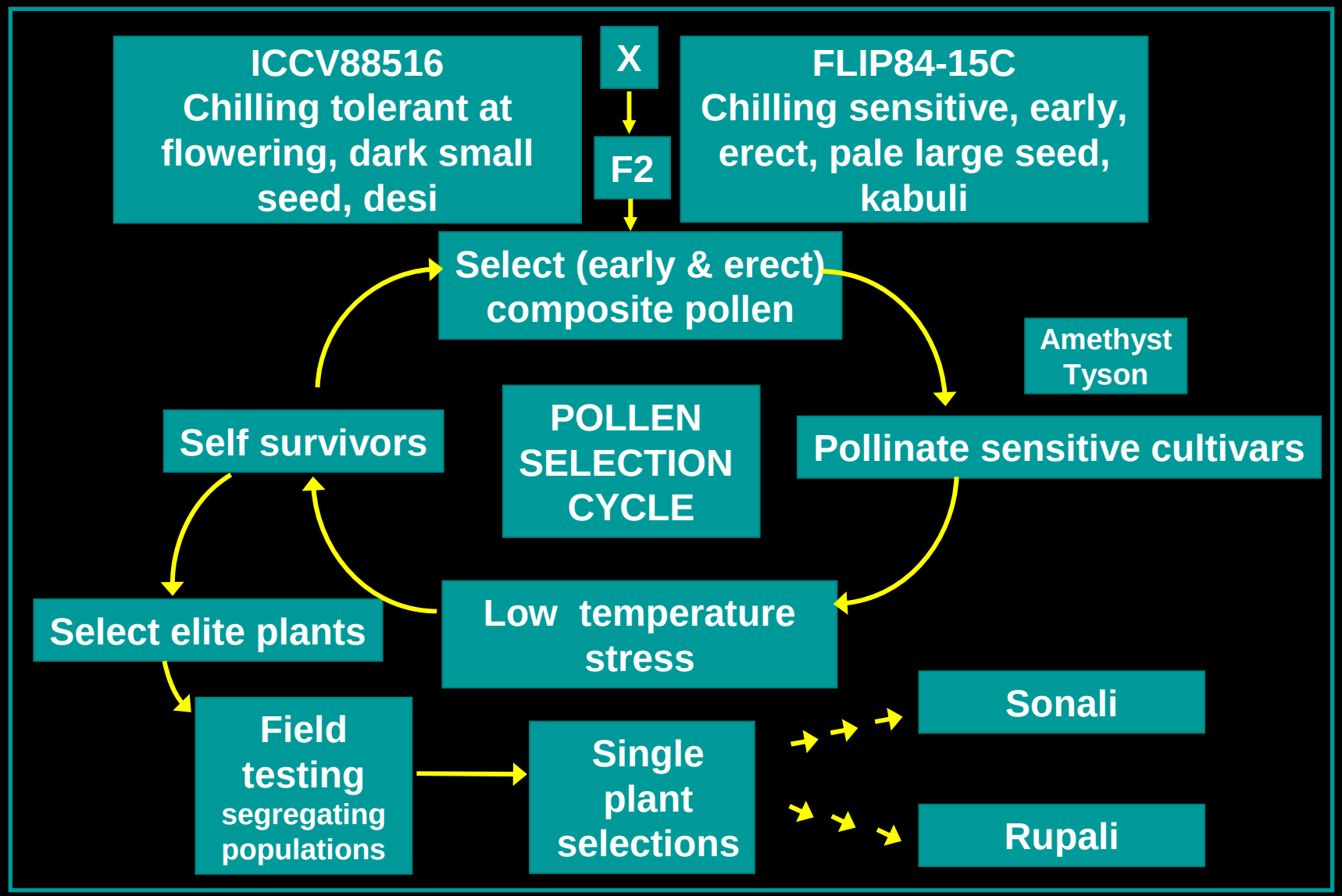
Almaz & Nafice launch at Mingnew August 2005

Development of cold tolerant chickpea varieties



Clarke and Siddique (2004) Field Crops Res.

Development of cold tolerant chickpea varieties



Clarke, Khan and Siddique (2004) Euphytica

Breeding team – Sonali and Rupali

Kimberley Large – at Kununurra

Lentil crop (Cassab)

5. Conclusions

Opportunities for grain legumes

- Increased disease and pest resistance
- Superior grain quality in food legumes (size and colour)
- Improved weed management in grain legume rotations
- Greater yield stability

Grain legumes area (ha) in WA

Species	Peak area*	Current area	Potential area
Narrow leaf lupin	1 200 000	700 000	1 400 000
Yellow lupin	4 000	1 000	200 000
Albus lupin	30 000	1 000	50 000
Chickpea	80 000	6 000	200 000
Field pea	90 000	90 000	250 000
Faba bean	40 000	10 000	150 000
Lentil	5 000	3 000	25 000
Vetch	15 000	11 000	60 000
Total	1 444 000	822 000	2 335 000

***Reduction in peak due to:**

Diseases in pulses and albus lupin
Aphids in yellow lupin
Yield, cost of production and low prices in lupin
Drought (2000, 2001 and 2002)

Participatory Research and Development

Conclusions

- Our research during the past 10 years has demonstrated how a number of cool-season grain legume species are adapted to fine textured soils
- Field pea was the highest yielding species at low yielding sites (<1.2 t/ha) while faba bean produced the highest seed yield under more favourable conditions
- The major traits of adaptation for grain legume species producing large yields in short season Mediterranean-type environments are early flowering, pod and seed set before the onset of terminal drought

Conclusions (cont'd)

- Robust production packages for key pulse species have been developed. These packages should be demonstrated and extended to growers
- Resistance to a number of fungal pathogens, especially in chickpea and faba bean, is a pre-requisite for the future
- Breeding and early generation evaluation of key pulse species in regional environments is a high priority for the future