Grain legumes in Australia

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Scope of this review and statistical problems

This review considers the current status of several species of grain legume (pulse crops) in Australia. The species are the winter growing temperate Chickpeas (Cicer arietinum), Faba beans (Vicia faba), Lentils (Lens culinaris), Lupins (mainly Lupinus angustifolius but also includes L. albus) and Peas (Pisum sativum); and the summer growing tropical and semi-tropical species, Cowpeas (Vigna unguiculata), Mung beans (Vigna mungo and V. radiata), Phaseolus beans (Phaseolus vulgaris) and Pigeon peas (Cajanus cajan). The oil-bearing legumes, soyabean and peanuts, are not discussed but many of the comments will also apply to them.

Because of the brief nature and wide coverage of the review I have attempted to find the common threads in the current situation for the several grain legume species grown in Australia. There is not space available to examine in detail the different species and the reader is referred to other recent reviews (1, 2).

There are some problems in interpreting the Australian statistical records (3) and time trends must be treated with caution. Peas and cowpeas are grouped together in the production stastistics; and phaseolus beans were recorded separately until 1984 when they were placed in the "others" category. Lupins, however, were only removed from the "others" category in 1978, when they constituted some 60% of the total grain legume production of Australia.

I have estimated the areas of lupins and peas over time as follows: all peas/cowpeas in the states of New South Wales (NSW), Victoria (Vic) South Australia (SA) and Western Australia (WA) have been called peas, those from Queensland (QLd) have been called cowpeas. During much of the time the area of peas/cowpeas in NSW was very small, therefore mis-identification will not seriously bias the estimate of the total pea area.

For lupins over the period 1971-1977, I have taken all the "other" category of Western Australia to be lupins, but for NSW, Victoria, and SA, I used a nominal figure of 90%. This estimate is unlikely to be seriously biased as it is only since 1981 that the "others" category has grown significantly. During the period 1967-1980 the average total area for all other grain legumes (excluding peas/cowpeas, lupins and phaseolus beans) in Australia was only 6800 ha . This included soyabeans, which were only removed to the oilseed category in 1980.

Now that grain legumes are becoming major crops in their own right, it is important that the Bureau of Statistics be requested to record individual statistics for each crop. This will allow better long term planning and priority setting on an objective basis.

As interest in grain legumes in Australia is only now beginning to "take off", much of the information on these species has not yet reached the formal literature. This review therefore relies heavily on Departments of Agriculture extension information and personal communication.

The international statistics tend to be both out of date and of low reliability (4), particularly for grain legume production, demand and trade. This is because the major areas of production and consumption are in the less developed countries, where accurate statistics are more difficult to obtain, as most production is for immediate consumption and demand is highly variable depending on season.

World production and Australian trends in grain legume production

World production of grain legumes in 1983 was about 43.5 million tonnes; of this the most important species was phaseolus vulgaris with some 13 million tonnes. Next in order of importance were peas, chickpeas and faba beans, accounting between them for a further 20 million tonnes. Lentils, mung beans, cowpeas and pigeon peas account for a further 8 million tonnes. World lupin production was about 0.7 million tonnes (5). Various other minor species make up the difference.

Australian production of grain legumes in 1984 was approximately 0.8 million tonnes, or about 1.8% of total world production (3,5). However world trade in grain legumes is small, but increasing, being about 3.42 million tonnes in 1983/4, 3.75 million tonnes in 1984/5 and 4.05 million tonnes in 1985/6 (6). In 1984/5 Australia exported some 0.4 million tonnes of grain legumes (3), 11% of world trade. However this figure over-estimates our importance in world grain legume trade as most of our production was in fact used as a protein source for animal feed, where it competes directly with soya bean and groundnut meal (world production of these is about 93 million tonnes, 5). Since 1984/85 Australian production has soared, particularly for peas and chickpeas, both species with a recognised human food market and for lupins which have been accepted recently by the Australian National Health and Medical Research Council as suitable for human consumption. The statistics for world grain legume trade in 1985/86 are given in Table 1.

Table 1: World Trade in Grain Legumes 1985/6 (6)

Species	Million tonnes
Chickpeas	0.17
Faba beans	0.28
Lentils	0.35
Lupins	0.34
Peas	1.40
Phaseolus beans	1.20
Others	0.31
TOTAL	4.05

In the last 20 years Australia has been in the midst of a crop species and production revolution due to the rapid adoption of grain legumes into the farming system. The area sown to grain legumes has increased 53 fold during the period 1967-1986 (Figure 1), increasing steadily during the period 1967- 1980, from about 24000 ha to just under 200,000 ha. Since then, expansion in area has been very rapid to an estimated 1,328,000 ha in 1986. In 1987 the total area sown to grain legumes will to be close to 2,000,000 ha.

When we remember that in 1979 the total area of grain legumes was 160,000 ha, the scale of the recent expansion is made clear. Two states (NSW and SA) now each plant this area to grain legumes, Victoria plants one and a half times this area, whilst Western Australia plants 4 times the total area sown in 1979 (Table 2).

Examination of the time-trends in total area sown shows that expansion of lupin and pea areas were, until recently (1984), the main cause of the rapid increase in grain legume production (Figure 1). The time-trends for areas of grain legume production by states are given in Table 2, showing that to date the greatest expansion has been in Victoria (mainly peas) and Western Australia (mainly lupins). In 1986 Western Australia accounted for 55% of the total area sown to grain legumes in Australia and in 1987 is expected to have approximately 1,000,000 ha of lupins. With current uncertainties about cereal prices, areas of grain legumes are expected to increase significantly in all mainland states in 1987. Tasmania has had no increase in the area of grain legumes during the past 20 years.

	Year 1971	1976	1981	1986*
New South Wales	14	4	22	162
Queensland	13	14	17	74
South Australia	14	24	69	162
Tasmania	2	1	1	1
Victoria	6	6	60	256
Western Australia	27	96	98	674

* Data from (3) and from personal communication with many scientists arround Australia.

Apart from lupins and peas it is only in the last 3 years that other grain legumes, particularly chickpeas and faba beans have contributed reasonable areas to Australian production (Figure 1 and Table 3). The increase is chickpeas has been spectacular, from 3000 ha in 1983 to an estimated 80000 ha in 1986 (E.Knights and others, pers comm).

The 1986 estimates of the areas of different grain legumes by states are given in Table 3. The figures are from the preliminary data of the Australian Bureau of Statistics and from personal communication. It is likely that adjustments to the total figures will be small when the full statistics are known in 1988.

The major crops are peas (mainly in Victoria and S.A.) and lupins

Table 2: Area (000 ha) sown to grain legumes by states.

	Year 1971	1976	1981	1986*
New South Wales	14	4	22	162
Queensland	13	14	17	74
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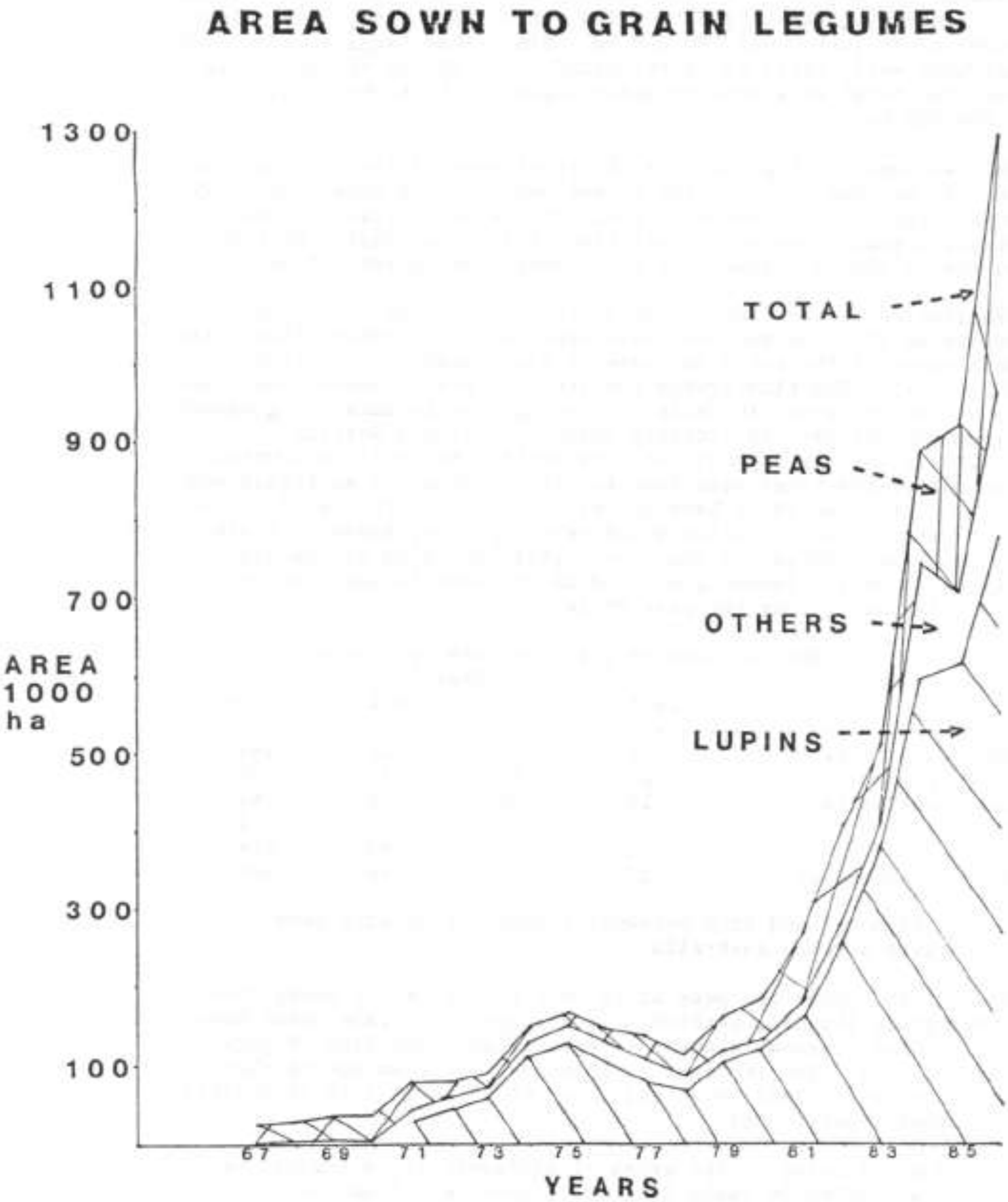

(W.A.). However several crops now have a larger area of production than the total area planted to grain legumes in 1967 (24000 ha). In fact the only crops with less than 24000 ha are lentils, pigeon peas and phaseolus beans. As new markets are developed the areas of pigeon peas and phaseolus beans are expected to increase substantially, also as the agronomic and varietal problems are solved so the area of lentils (a high value legume, 30) is expected to increase.

Table 3: The estimated area of different grain legumes in Australia in 1986 by states (000 ha).

CROP	NSW	Qld.	STATE SA	Vic	WA	TOTAL
Chickpeas	18	51	4	7	-	80
Faba beans	4	-	30	4	1	39
Lentils	.5	-	1.5	1	-	2
Lupins	60	-	27	24	663	774
Peas	35	-	100	220	10	365
Total (Winter)	117.5	51	162.5	256	674	1260
Cowpeas	24*	7	-	-	-	24
Mung beans	15	10	-	-	-	25
Pigeon peas	5	3	-	-	-	8
Phaseolus beans	.2	10	-	-	-	10
Total (Summer)	44.2	23	-	-	-	67
Grand Total	161.7	74	162.5	256	674	1327

* includes areas grown for dual purpose grazing or seed.

In terms of markets two facts stand out. First, Australia has the potential to become a major producer of grain legumes for human consumption. Second, in terms of total world grain legume protein production (including soyabean and ground nuts) Australia is and will remain a small scale producer. Provided we can produce grain legumes cheaply enough to compete with soya bean meal (discounting prices for protein percentage and quality) we will be able to sell our production. This provides the economic benchmark for the viability of any grain legume industry (88). If the seed is suitable, the human food market provides a major bonus. However, interventionist policies in importing nations and price instability are likely to have major effects on markets and profitability (88.). As reasonable tonnages of legumes for human consumption are produced, there is a need for more market information (17,39,88). This will ensure that the product matches demand and specification. There is a need for a more formal approach to gathering and distributing this information. Currently it is often on a local or ad-hoc basis. Interstate rivalry may be dis-advantageous to the rapid and effective development of markets.

There is also a large potential internal market for grain legumes for sheep and cattle production, but this has been little explored.

Areas of adaptation by grain legumes in Australia

The ecological range covered by the grain legumes considered here is large and ranges from tropical to cool temperate. The within-species range is also being increased as a wider range of germplasm is introduced into Australia. Table 4 presents some of the data that determines the ecological range of the species.

The effect on flowering of photoperiod and vernalisation requirement, if any, is under quantitative genetic control (2,7, 8,9,10,11,12,13,14,15,16,17,18,19,20,21,22) and day neutral types are being selected in many breeding programmes. Once any vernalisation requirement has been met all species show increased rate of development with increasing temperature (7,8,9,10,11,12, 18). Day-neutral types will increase the adaptability of varieties. Selecting these types is a sensible policy within Australia, where there is usually only a single breeding programme for each species. Producing varieties with the potential for wide adaptation to variable daylength will increase the likelihood of varieties being well adapted to regions distant from their place of breeding. The success of both Dun peas and several lupin varieties, over a wide range of latitudes, indicates this potential.

Most species are strongly in-breeding and this aids maintenance of varietal purity (7,9,10,11,12,13,15). However two species, faba beans and pigeon peas, have appreciable degrees of out-crossing (8,14). As the area sown to these species and the number of available varieties increases maintenance of varietal purity may become a problem (23).

There is a wide variation in the adaptation of species to soil type (23,24,25,26,27,28). Some species have a wide adaptation (lentils, peas, cowpeas 24,25,27). Others, particularly lupins (24, 28), have a more restricted range. No species is well adapted to waterlogging, although faba beans are more tolerant of this than the other species (24,29). Two species, (lentils, pigeon peas) are highly in-tolerant, to the point that irrigation can be risky (23,30). The range of soil pH to which species are adapted is wide (24,26,31), although in many cases the range is not well defined.

Five species are adapted to the Australian winter growing mediterranean environment and four are adapted to semi-tropical summer growing conditions.

Besides the characters listed in Table 4, there is a range of drought susceptibility between the species, with peas, faba beans and phaseolus beans being most susceptible (18,24), lupins, on sandy soils, chickpeas, lentils and cowpeas are moderately resistant (24,32) (note lupins on heavy soils in medium rainfall areas are drought susceptible, 24). Mung beans and pigeon peas are drought hardy (23,27). However these difference are relative and drought is capable of reducing yields of all species to very low levels (23). In some species, especially peas and mung beans, drought escape is an important way of avoiding the worst effects of drought.

Table 4: SOME FACTORS THAT DETERMINE THE ECOLOGICAL RANGE OF GRAIN LEGUMES IN AUSTRALIA

SPECIES	PHOTO-PERIOD RESPONSE	POLLINATION	VERNALISATION	SOIL TYPE	WATERLOGGING	GROWING SEASON	pH
Chickpeas	Quantitative long day	Self pollinated	None ?	Well drained medium loams and clays	Intolerant	Winter/spring	5.5 - 9.0
Faba beans	Quantitative long day	Cross pollinated, but selfed types available	Quantitative response	Deep alluvial and clay soil	Moderately tolerant	Winter/spring	6.0 - 9.0
Lentils	Quantitative long day	Mainly self pollinated	Quantitative response	Various if well drained not sands	Intolerant	Winter/spring	5.2 - 9.0
Lupins	Quantitative long day	Mainly self pollinated	Quantitative response	Deep yellow sand and sandy loam	Slightly tolerant varies with species	Winter/spring	4.2 - 7.5 higher if no free lime
Peas	Quantitative long day	Mainly self pollinated	Quantitative response	Various if well drained not sands	Intolerant	Winter/spring	5.5 - 9.0 ?
Cowpeas	Quantitative short day	Mainly self pollinated	None	Various if well drained	Intolerant	Late spring summer	5.5 - 8.0 ?
Mung beans	Quantitative short day	Self pollinated	None	Well drained loam and clay not sands	Slightly tolerant	Late spring summer	5.0 - 8.0 ?
Phaseolus beans	Quantitative short day	Mainly self pollinated	None	Various if well drained	Intolerant ?	Late spring summer	5.5 - 7.5 ?
Pigeon peas	Quantitative short day	Much cross pollination	None	Loam to clay if well drained	Highly intolerant	Late spring summer	5.5 - 7.5 ?

In conclusion, the range of adaptation of grain legumes species in Australia is wide. There should be a species to fit most of the cropping regions of the country. The situation will improve as plant breeders produce new and more widely adapted varieties. It is unlikely that varieties which are highly tolerant of waterlogging will be developed in the near future.

Agronomic problems of growing grain legumes in australia

Three problems are very frequently mentioned by grain legume scientists in Australia. First, weed control is difficult, particularly post-emergent control of broad-leafed weeds during early growth when all species, except faba beans, are poorly competitive with weeds (17,24,27,28,29,30,33,34,35,36,37,38,39, 40,41,42,43,44,45,46,47,85,86). There are few herbicides available for this period of crop growth and weeds are a major constraint on high production. For mung beans these problems are so severe that planting is not recommended if broad leafed weeds are present (27,86). The situation will improve as more chemicals become available and are tested. For example Diflufenican (May and Baker) is being tested on a farm scale in 1987 for post-emergent radish control in lupins (35,41,43). An alternative approach is to use swathing to reduce weed contamination and uneven ripening problems at harvest (48,49,50). However this has no effect on weed competition during the growing season, or on weed burden for the following crop. Swathing is a rescue operation rather than a weed control system.

The second general problem is in pest and disease control. Although many insect pests and diseases were mentioned by research workers, these were mostly species and/or region specific. However, an area of general concern is the importance of Heliothis species as major pests of grain legumes (27,29,30, 33,34,36,38,39,42,43,44,45,51,52,53,54,85,86). A very wide range of both crop and wild species, are attacked by Heliothis spp. The susceptibility of the latter makes population reduction difficult. Also it is unlikely that resistant varieties will be available in the near future (Walden, pers comm). The insects cause damage in two ways, first by reducing the yield of the crop and second by reducing the quality. The scale of the problem has been recognised by Grain Legume Research Council (GLRC) which is suporting studies into the importance, biology and control of Heliothis (Robson, pers comm.).

Another disease area about which I feel some concern is the potential for the root rot fungus, Rhizoctonia solani, to become a major problem in cereal/lupin rotations, and possibly in other grain legume/cereal rotations (33,38,55). Strains of this pathogen exist which are virulent on both cereals and legumes (55). It is possible that as grain legumes become more important, the damage this fungus causes will increase. This has worrying implications for crop rotations in situations where cultivation to control the disease seriously increases the wind erosion hazard.

The third major area of concern is in variety by planting date interactions . Ensuring the optimum planting date has a large impact of yield potential of many grain legumes (17,27,28,29, 30,33,35,37,39,43,47,52,53,56,85,86,87). This is because of relationship between seasonal stresses, predominantly frost risk at flowering and drought during grain filling, and the development pattern of yield in many grain legumes.

Most grain legumes flower over an extended period, as inflorescences develop sequentially on progressively later formed nodes or on later formed branches. This flowering pattern has several disadvantages. In winter growing species it puts early formed flowers and fruits at risk from frost. If delayed planting or late flowering types are used to avoid this risk then late formed flowers and fruits are at risk from drought. In summer growing species the risks may be reversed. This flowering pattern also often leads to un-even ripening of the crop and harvest difficulties. As grain legumes often have a tendency for pods to shatter or shed, this delay can reduce harvested yields. Also certain environmental conditions, which are not yet clearly defined and which will probably vary with species, cause many grain legumes to become excessively vegetative and low yielding, particularly in relation to the biomass produced, that is they have low harvest indices.

The current attempt in many breeding programmes to get more control over flowering pattern, vegetative growth and partitioning of biomass into seed is a possible solution to this problem (23„57,58,59,60,61, 62 and J-B. Brouwer, pers comm.) for lupins, peas, pigeon peas and phaseolus beans. Variation is available for control in other species, but has yet to be

reported on in Australia (8,12). Control of vegetative growth and flowering period will allow better matching of genotypes to the environment, and hopefully higher and more consistent yields.

Varietal situation

There is a marked relationship between the length of time that a breeding programme has been conducted and the number of recommended grain legume varieties that are available. The most recommended varieties available are for lupins (all either bred or initially selected by John Gladstones) and peas. In terms of breeding effort the lupin/pea situation is probably a lesson for us all. Gladstones' programme commenced in 1954 (63) and he released his first variety, Uniwhite, in 1967. Since then another 8 L. angustifolius varieties have been released from this programme (Uniharvest, Unicrop, Marri, Illyarrie, Yandee, Chittick, Danja, Wandoo, and Geebung 35,63,64) as well as 3 varieties of L.albus and one of L.cosentinii. There has been a rapid improvement in yield potential in these varieties (Fisher pers comm). Phomopsis resistant and reduced branching types are likely to be released in the near future (59,65,66). This is the longest continually running grain legume breeding programme in Australia, and is recognised as the leading breeding programme for L. angustifolius in the world. In contrast to lupin variety development, Dun peas were introduced at the turn of the century. Since then there has been spasmodic breeding effort and varietal releases until recently when the current Victorian and South Australian programmes were started (61). These are now beginning to have an effect on variety release (61). However Dun is still a consistently high yielding recommended variety, although this situation is likely to change (61).

The contrast between pea and lupin breeding effort provides a good lesson for other grain legume breeding and agronomic programmes. It shows the importance of continuity and dedication when it comes to the production of improved varieties and agronomic systems. If we hope to repeat this in other grain legumes, then stop-go programmes are unlikely to deliver.

At the other extreme to lupins is lentils, where only a little screening work has been carried out to date. The currently recommended variety is of Canadian origin although a farmer's un- named introduction is also being grown and a new release is expected shortly from NSW. It is noticeable that there are several new varieties just being released and recommended for several grain legumes.

The currently recommended varieties are listed in Table 5, below.

Table 5: Currently recommended varieties of grain legume

Grain Legume	Current Varieties	Recent Releases
Chickpeas	Garnet, Opal, Tyson	Amethest, Dooen
Faba beans	Fiord	
Lentils	Laird	L11
Lupins	Uniharvest, Unicrop, Illyarrie Yandee, Chittick, Ultra	Geebung, Danja, Wandoo
Peas	Dun, Dundale, Derrimut Pennant, Collegian,Buckley	Alma, Maitland, Wirrega
Cowpeas	Poona, Caloona	Red Caloona, Banjo
Mung beans	Berken, Celera, Regur	King
Phaseolus beans	Kerman, Gallaroy, Actosan Actolac	Revenue, Banker
Pigeon peas	Royes, Hunt	Quantum

The impact of Plant Variety Rights (PVR) legislation on the current collaboration between states on variety production and testing has not yet been worked out. However as there are so few programmes in Australia covering the many grain legumes, that it is important that current inter-state co-operation is not restricted (Gladstones pers comm).

Rotational benefits from grain legumes in crop rotations

The grain legume species that has been most intensively studied in Australia for its residual benefits to following crops in rotation is lupins. The two groups which have carried out most work on lupin residual value are Reeves and co-workers at Rutherglen (for review see 67) and Rowland and co-workers in Perth (68,69). In a recent review Rowland et al. (69) identified 130 site/years of lupin residual value data from throughout Australia . The average yield of wheat after lupins was 1.87 t/ha, whereas the yield of wheat after wheat was 1.29 t/ha; an advantage to the wheat lupin rotation of some 45%.

It has been estimated for lupins that the non-nitrogen residual effects in rotation, on average, account for half of the response measured in cereals. (69). However in any particular situation the importance of particular components will vary.

Less extensive studies suggest a similar range of response by cereals to chickpeas, faba beans and peas in rotations (70,71, 87). Data for other species in Australia is limited, but results from other parts of the world suggest that the species considered here play an important role in rotations (2).

Excluding nitrogen effects (see later) the roles of legumes in rotations are subtle and complex. Some benefits will be general to all legumes. For example modern grass killing herbicides allow excellent disease cleaning against several root diseases for following cereal crops [Cereal cyst nematode, Heterodera avenae (72,89,90), Common root rot, Cochliobolus sativus/Bipolaris sorokiniana (73,74) Take all, Gaeumannomyces graminis, var tritici (72,75,76,77,78), Eye spot, Pseudocercosporella herpotrichoides (66,70,78) and crown rot, Fusarium graminearum (78)]. At the same time there is the opportunity of reducing grass weed problems for the cereal phase (34,79).

However, some effects are restricted to particular species and/or soil types. For example, deep tap rooted species may cycle potassium from depth, as has been shown for lupins (68). Likewise deep rooted species may use more water from depth than shallow rooted species such as peas or medics (80,81,Hamblin unpublished data). Thus deep rooted grain legumes may lessen he problems of rising water tables (80). Tap rooted species may not be as affected by hardpans as fibrous rooted species. It has been shown that lupins show little response to deep ripping (81,82,83). Henderson (pers comm) has shown that lupins reduce the effect of soil compaction on a following wheat crop and was able to demonstrate both a reduction in soil penetration resistance and improved wheat yields. There is evidence that lupins in rotation help to improve soil structure (53,66) compared to continuous cereals. Less data are available in Australia on these effects in species other than lupins. However it is unlikely that nutrient cycling (other than nitrogen), or effects on hard pan reduction, will be important in shallow rooted species such as peas. Also the effects, which have been demonstrated on deep sandy soils, may not be important on heavier soils with better nutrient and water holding capacity.

Besides these positive effects of grain legumes, there are some potential negative effects. Lupins have been implicated for increasing water repellancy in light soils (Summers pers comm), making them more liable to wind blowing and poor crop establishement (69). There is evidence that certain strains of Rhizoctonia are common to both cereals and lupins, which will increase this disease problem unless appropriate cultivation techniques are used (55). There is also concern about grain legumes increasing soil acidity (39), however this has yet to be established.

Nitrogen fixation by grain legumes

Australia has a long tradition of using biologically fixed N in its farming systems, mainly from subterranean clover and medic based pastures (68). The experience of rhizobium strain testing and production has been applied to grain legumes (84), so that high quality inoculum is available for all the species of grain legume grown in Australia. When infected with a suitable strain of Rhizobium all the grain legumes grown in Australia are capable of fixing nitrogen. However, for some of the species there is little local evidence as to their N fixing capacity, but the literature shows that all are capable of fixing significant amounts of Nitrogen (Table 6). Actual fixation will depend on many factors, including soil nitrogen levels, crop growth, host and rhizobial genotypes, growing season conditions etc. Estimates from the literature for the range of N fixation be the various grain legumes is given below (Table 6).

Table 6: Estimates of N fixed (kg/ha) by various grain legumes when innoculated with effective Rhizobium

There are no obvious differences in the potential of both winter and summer growing legumes to fix Nitrogen. All grain legumes crops in Australia have the potential to improve the nitrogen

status of the soil for the following crop. However the amount of any increase that is available to a following crop will depend on many factors, including the actual amount fixed, the amount carried off in grain yield of the legume, factor affecting the breakdown of the residual N and leaching and/or volatilization of the mineralised portion, and whether or not the crop residues were grazed.

Australian yield trends with time

Published data are only available for peas and lupins over the period 1973-1985, with estimates of 1986 production. For the 7 years of the 1970's which were studied, the average yield of lupins was 0.64 t/ha and that of peas 0.98 t/ha. For the 7 years of the 1980's the corresponding yields were 0.90 and 1.10 t/ha respectively. This is an improvement of 41% for lupins and 12S for peas. During this period the average area sown to lupins and peas has increased greatly (Figure 1). The learning curve, by both scientists and farmers, has been dramatic. Not only has area increased, but so has output per ha. Whether this trend can be sustained into the future remains to be seen. However, I am reasonably optimistic that this will occur as there is both considerable interest in grain legumes from farmers and also a willingness to turn to scientists for advice on how to grow grain legumes better. There is a real opportunity to show the potential of research to increase farmers' yields as they have little historical experience to fall back on. The experience gained from lupins and peas is being used in the development of other grain legumes and research effort has increased. To ensure that momentum is maintained research cannot be on an ad hoc basis. It is important that the research levy is systematically gathered, which apart from lupins in Western Australia, is not currently the case (Robson pers comm). At the same time increased market information is needed to ensure good penetration into the export human food market. When better times return for cereals the role of grain legumes in rotations will be widely appreciated and the benefits of risk spreading will hopefully ensure that grain legumes are not relegated to the role they played in the 1960s'.

Crop	Range of N fixation	Average	Source
Chickpeas	1 - 114	57	7,70,
Faba beans	30 - 600	329	8,70,75
Lentils	35 - 115	75	9
Lupins	30 - 258	35	10,69,70,75
Peas	17 - 119	68	11,70,75
Cowpeas	25 - 354	189	12
Mung beans	58 - 107	82	13,17
Pigeon peas	13 - 113	63	14,23
Phaseolus beans	64 - 121	92	15

Conclusions

1. A revolution is going on in Australian agriculture with the very rapid development of several grain legume species which, in the last few years, have changed from cropping oddities to major crops in their own right.

2. To ensure the continued development of these species, development of suitable markets for the produce is urgently needed.

3. The base line for long term production of grain legumes is to be profitable at the price paid for animal protein feed. Any extra value from the human food market is a bonus.

4. Grain legumes in Australia have wide adaptation between species and it is likely that with improved new varieties, most of the cropping areas of Australia will be able to grow at least one grain legumes species.

5. There are active research programmes on the best suited legumes in all mainland states.

6. Most species also have active breeding programmes. As these are often aimed at breeding daylength insensitive types, new varieties should be widely adapted. As it is unlikely in the foreseeable future that there can be several programmes on each species it is important that interstate collaborative testing is conducted. This will ensure that varieties suitable to local conditions are identified early in the breeding programmes. The effect of PVR on current collaboration has not yet been identified or addressed.

7. Certain problems are common to all grain legumes:

post-emergent broad leaf weed control, Heliothis insect damage,

Variety x planting date interactions and poor partitioning of biomass into grain yield.

8. All grain legumes have a significant role to play in rotation, mainly through residual N effects, disease cleaning and grass weed control. However, particular species may have several other roles in rotations and these need to be identified.

9. Potential problems from having grain legumes in rotations include:

the build up of soil non-wetting problems, the potential increase in some diseases possible effects on soil pH.

10. There is a need to ensure that adequate funding goes into grain legume research to support the long term development of these crops. A research levy collection system which ensures that all growers (and not primarily WA lupin growers) contribute to grain legume research is urgently needed. This problem should be seriously addressed by both farmers and research organisations.

11. There is a need for better statistical records to be taken by the ABS, as many grain legumes are now contributing substantially to Agricultural production.

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