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WORLD PRODUCTION AND TRADE IN GRAIN LEGUMES

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ABSTRACT

Compared with the major cereals the annual world production of grain legumes is relatively small and amounts to 171 million t. Only about 21% of this production enters international trade and trade in grain legumes is dominated by a single species the soya bean, which in 1987 accounted for 82% of the total trade. However, imports of other grain legumes into Europe and South East Asia have increased rapidly in the last ten years and these two regions combined with Latin America account for 78% of the total tonnage traded. With a knowledge of which grain legumes are preferred in a particular market it is possible to deduce which species are most likely to be in demand.

For New Zealand it appears that besides our traditional market in peas export opportunities exist for sale of lentils and Desi chickpeas in the Indian sub-continent, large seeded faba beans in North Africa and the Arabian Countries and dry *Phaseolus vulgaris*, Kabuli chickpeas and lentils in Europe. Latin American imports are probably mainly dry *Phaseolus vulgaris*.

On the local market opportunities exist for import replacement of peanuts, which can be grown in the north of the North Island and for dry *Phaseolus vulgaris* for production of baked beans, as appears to have happened since 1987. Finally, New Zealand currently imports $NZ 32 million worth of of soya bean products a year. There is no apparent reason why these could not be produced from locally grown and processed beans.

PRODUCTION

For thousands of years legume seeds as a source of human food have enjoyed a poor press. Even in the Bible legumes are referred to as poor mans' meat. Studies which relate per-capita income with grain legume consumption by humans have shown a strong negative relationship between the two at both the national and international level (Aykroyd & Doughty, 1964). However, considerable amounts of grain legume seed are consumed by humans in the developing countries as a high protein supplement to cereal based diets. Further, as people in the developed countries become more conscious of the effect of eating large amounts of animal products on their health, the consumption of pulses has been rising.

Major traditional species are faba beans (*Vicia faba*) in China, North Africa and around the Mediterranean basin, Desi chickpeas (*Cicer arietinum*), lentils (*Lens culinaris*), and pigeon pea (*Cajanus cajan*) on the Indian sub-continent, soya beans (*Glycine max*) in China, Indonesia and Japan, common beans (*Phaseolus vulgaris*) in Central and South America and cow peas (*Vigna unguiculata*) in West Africa.

Besides these major species there are a number of minor legume species that are also used in human diet. These include *Lupinus albus* in the Southern Mediterranean region, *Lupinus mutabilis* in the Andean region of South America, *Dolichos uniflorus*, *Lablab niger*, *Lathyrus sativus*, *Psophocarpus tetragonolobus* and *Vigna radiata* in Asia, and *Phaseolus lunatus* in the Americas. Figures for the world production of these species are not readily available and similarly, probably little enters world trade. However, because of their specific climatic adaptation and their ready dietary acceptance they are all important at a local level.

In trade and production statistics peanuts (*Arachis hypogea*) and soya beans are not included with the pulses (FAO, 1988a,b,c). Presumably this is because of their importance as oil seed crops. However, as the residues left over after oil-crushing are an important protein source for feeding of both monogastric and ruminant livestock particularly, in North America, Europe and Japan they are in direct competition with the other grain legumes. Therefore, they will be discussed in this paper with the other pulses.

WORLD PRODUCTION

The total world area sown to all grain legumes in 1987 was 138.4 million ha. This area gave a total production of 171.4 million t (Table 1). Production of grain legumes was considerably below that of most of the major cereals which amounted to between 400 and 500 million t. The amount produced was roughly equivalent to that of barley (178.5 million t)(FAO, 1988a).

Table 1. Total world production of grain legumes and selected cereals, 1987.

Crop	Production (10^6 t)
Wheat	516.8
Maize	457.4
Rice	454.3
Barley	178.5
Grain legumes	171.4

Of total grain legume production 51.6 million ha and 98 million t was from soya beans (Table 2). Major soya producing nations are the United States (22.8 million ha; 51.2 million t), Brazil (9.2 million ha; 16.9 million t) and China (8.4 million ha; 12.1 million t). Next in importance in terms of total production are peanuts (Table 2). Peanuts are not currently grown commercially in New Zealand but North Island trials have indicated their potential (Anderson & Piggot, 1981). Total world production in 1987 was 20.1 million t from 18.1 million ha. Current major producers are China (3.1 million ha; 6.1 million t), India (6.3 million ha, 4.5 million t) and the United States (0.6 million ha; 1.6 million t)(FAO, 1988a).

Among the legumes production then falls to peas at 14.5 million t (Table 2) grown on 9.8 million ha. Countries which produced over one million tonnes of peas included Russia (6.8 million t), China (1.9 million t) and France (1.8 million). Across the Tasman Australian production of peas has increased from 55,000 t in 1981 to 887,000 t in 1987 (FAO, 1988a).

Almost as many dry beans are produced as peas (Table 2). World production in 1987 was 14.0 million t grown on 26.6 million ha. Average world yield is low at 558 kg/ha. Major producing nations are Brazil (2.0 million t; 5.2 million ha), the United States with considerably higher yields (1.2 million t; 0.7 million ha) and Mexico (1.0 million t; 2.3 million ha). The figures for India at 2.5 million t from 9.2 million ha and China 1.6 million t from 1.4 million ha suggest that all of the production data reported in Table 32 of the FAO Production Yearbook 1987 (FAO, 1988a) are not derived from the same legume species as *Phaseolus vulgaris* is not generally considered to be a major crop in India.

Table 2. World production of individual grain legumes , 1987.

Crop	Production (10^6 t)
Soya beans	98.0
Peanuts	20.1
Peas	14.5
Phaseolus	14.0
Cicer	6.8
V. Faba	4.5
Lentils	2.6

Chickpeas are next in importance in terms of world production (Table 2). For this crop, world production is dominated by India, which produced 4.5 million t from 6.7 million ha which was 65 % of total world production. It is probable that the majority of the chickpeas produced in India are the red, small seeded Desi type rather than the large cream Kabulis which are more sought after in the developed world. Other major chickpea producers are Turkey (750,000 t from 666,000 ha) and Pakistan, again probably mainly Desi (583,000 from 1.1 million ha)(FAO, 1988a).

Production then falls still further to *Vicia faba* at 4.5 million t. China is the single major producer at 2.4 million t. However, it is a popular crop in North Africa with Ethiopia producing 480,000 t and Egypt (where it a popular staple of diet (ICARDA, 1985)) 323,000 t. In Western Europe both West Germany and Italy produce more than 175,000 t (FAO, 1988a).

The final crop to be given separate status in the FAO statistics (FAO, 1988a) is lentils at 2.6 million t. The major producer is Turkey with 950,000 t. Other large producers are India (666,000 t) and Canada (328,000 t). New Zealand does not feature in the international statistics of lentil production as the New Zealand Department of Statistics does not keep records of the area sown to this crop, or of the other grain legumes except for peas. However, if the exports of 2,400 t (Department of Statistics, 1989) are added to the estimated internal demand of 200 t suggested by Logan (1983) the total of 2,600 t suggests that New Zealand currently produces 0.1 % of total world lentil production.

WORLD TRADE IN GRAIN LEGUMES

Although the total world production of grain legumes is in excess of 170 million t only a small amount of this production enters world trade (Table 3). Soya beans were traded most and from 1985 to 1987 the amount of the crop entering trade varied from 25 % to 30 % of total production. In 1987 Europe imported 16.2 million t of soya beans with Great Britain, Belgium, West Germany, the Netherlands, Italy, Spain and Jugoslavia all importing in excess of one million t. In Asia Japan and South Korea imported nearly 6 million t (FAO, 1988b).

Table 3. A comparison of total production of grain legumes (excluding soya beans and penauts) and amount entering world trade, 1985-87.

Year	Production (10^6 t)	Trade (10^6 t)
1985	51.4	3.9
1986	53.4	4.6
1987	53.3	5.1

World sales of peanuts are probably of less direct interest to New Zealand. However, from 1985 to 1987 about 5 % of the total crop entered world trade (Table 3). As with soya beans major purchasers were in Europe which took nearly half the 1.1 million t traded (FAO, 1988b).

With regard to the remaining grain legume species totals entering world trade compared with production are small and from 1985 to 1987 ranged from 7.6 to 9.6 %. The total tonnages involved were never more than 5.1 million t a year. Unfortunately, the FAO Trade Yearbook (FAO, 1988b) does not distinguish among pulses so no specific information is available as to the major destinations of particular species.

TRENDS IN WORLD GRAIN LEGUME IMPORTS

Although it is not possible to distinguish among legume species as to their final destination in world trade it is possible to distinguish where major changes in imports are occurring (FAO, 1988c). Over the period from 1976 to 1986 there have been two major growth regions for grain legume sales (Table 4) (FAO, 1988c). Major increases in imports of grain legumes have occurred in Western Europe where imports rose from 821,000 t in 1976 to 2.1 million t in 1986. This was an annual rate of growth of 9.01 %. The rate of growth of legume imports in the South East Asian market has been even more spectacular. Over the same period imports rose from 90,000 t to 841,000 t. This was an annual growth rate of 23.64 %.

Table 4. Changes in imports of grain legumes to Latin America, South East Asia and Western Europe, 1976-86 (10^6 t).

Year	Latin America	South East Asia	Western Europe
76	0.30	0.09	0.82
77	0.40	0.09	0.89
78	0.29	0.16	0.91
79	0.28	0.21	1.05
80	0.82	0.21	1.01
81	0.88	0.38	0.92
82	0.74	0.38	1.07
83	0.52	0.37	1.31
84	0.51	0.47	1.43
85	0.61	0.56	1.87
86	0.52	0.84	2.09

Considering the large quantity of legume seed produced by countries such as Argentina, Brazil and Mexico it is surprising that Latin America is also a very significant market. Imports ranged from 291,000 t to 878,000 t during the period and were 523,000 t in 1986.

Annual market growth was 6.81 % over the eleven year period (FAO 1988c). In the rest of the world over the same period the volume of legume imports ranged from 620,000 t to just over 1 million t. Purchases by the rest of the world have virtually been static since 1981.

THE NEW ZEALAND SCENE

Peas as frozen vegetables, dried for human consumption and for sowing are the major grain legume exported from New Zealand (Table 5, 6) (Department of Statistics, 1989). In the year ending October 1989 the value of pea exports was $NZ 43.3 million (Table 5). The majority of the returns came from frozen peas either alone or mixed with other vegetables ($NZ 22.3 million). Significant returns also came from dried pea ($NZ 16.6 million) and pea seed exports ($NZ 6.8 million).

Table 5. Value of New Zealand legume based exports and imports (November 1988 - October 1989) ($NZ x 10^6).

Crop	Exports	Imports
Peas	47.1	-
Lentils	1.8	-
Soya beans	-	32.6
Phaseolus	-	7.3
Cicer	-	0.1

On the export scene in recent years probably the most spectacular increase has come form lentils. When Logan (1983) wrote her report she estimated that New Zealand had an internal demand for 200 t of lentils per annum and was importing 101 t. Exports in the November 1988 to October 1989 year, which followed a severe drought in the main growing area of Canterbury, were 2,374 t. Allowing for seed for resowing, this suggests total production of about 2,600 t per annum.

There has also apparently been a major change in New Zealand production of dry beans in the last few years. In 1885/86 dry *Phaseolus vulgaris* imports were 2,000 t which cost $NZ 2.4 million (Department of Statistics, 1987). By late 1989 New Zealand imports were only slightly greater than exports. The country imported 278 t and exported 250 t of dry beans. The majority of the production was exported as agricultural seed at an f.o.b price of $NZ 1,397 /t. However, further import savings are still possible as the import price (c.i.f.) was $NZ 2,056 /t (Department of Statistics, 1989).

Table 6. Value of New Zealand pea exports by product type (November 1988 - October 1989) ($NZ x 10^6).

Product	Value
Frozen	22.31
Dried	16.61
Seed	6.86
Other	0.55

Turning now to legume imports it is somewhat dismaying to find that the income earned from pea exports is almost equalled by the cost of imported soya bean products at $NZ 31.6 million (Table 5, 7) (Department of Statistics, 1989). As Wynn-Williams & Logan (1985) indicated there are no major agronomic problems with growing soya beans in New Zealand. The main limitation in the production of this crop is the absence of an oil extraction plant. The majority of the current imports derived from soya are in the form of oil at 20 million l. A tonne of soya beans yields about 150 l of oil therefore the amount of the crop that would need to be grown to produce this amount of oil would be approximately 136,000 t of soya beans. At an average yield of 2.5 t/ha this would require a crop area in excess of 54,000 ha. Further, this amount of seed would produce about 108,000 t of soya bean meal compared with current New Zealand imports of 2,946 t (Department of Statistics, 1989). This considerable excess of soya bean meal would have to be either absorbed by the local pig and poultry feed processing industry or exported.

The situation with peanuts is less complex. As there are no crushing facilities in New Zealand the 4,700 t that are imported are used for the confectionary trade and in the production of peanut butter. Over the last twelve months the average price of peanuts landed in New Zealand was $NZ 1,410 /t. Whether this would be an economic price for farmers to grow the crop locally will depend on the cost of production in New Zealand, and the yield obtained. An implied possible return of $NZ 3,800 /ha suggested by the results of Anderson & Piggot (1981) would, superficially, seem attractive.

Table 7. Value of New Zealand soya bean based imports by product type (November 1988 - October 1989) ($NZ x 10^6).

Product	Value
Oil	20.78
Meal	9.42
Sauce	0.87
Seed	0.51

The final legume imported in any quantity is chickpeas. Total imports were small, a mere 69 t for the 1988/89 year (Table 5). The average cost was $NZ 1,123 /t (Department of Statistics, 1989). Hernandez & Hill (1985), in Canterbury, obtained a yield of 2.7 t/ha of Kabuli chickpeas from a variety which had not been selected for the New Zealand environment.

Not featuring in the list of imports or exports but easily grown in this country is *Vicia faba*. Newton & Hill (1978) reported farm yields of up to 6.2 t/ha. ICARDA (1985) indicated that the average Egyptian consumed 9 kg of dry *Vicia faba* a year. The current population of Egypt is 49 million (FAO, 1988a) which gives an annual demand for this crop in excess of 400,000 t. Egypt currently imports 76,000 t of pulses each year. Thus *Vicia faba* would also appear to be a crop with export potential particularly the large seeded varieties.

CONCLUSIONS

There are a range of options available among the grain legumes for potential exports and for import replacement for New Zealand arable crop farmers and for food processing companies who wish to diversify their production by growing and processing grain legumes. Further work is required on the agronomy of some of the crops and certainly for some species varieties need to be imported or bred that are well adapted to the New Zealand environment. The remaining papers in this workshop will survey potential markets in greater depth and the review the current state of knowledge on grain legumes to identify future research priorities.

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TRADE IN WINTER GRAIN LEGUMES: A SOUTH AUSTRALIAN PERSPECTIVE

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INTRODUCTORY VISION

I was attending a communication seminar recently and remarked to that audience of strangers that I wondered why our Department of Agriculture people with their specialist grain legume knowledge, did not seem to have a team objective around building a grain legume industry. This group of strangers was able to provide me with a "conversation for the possibility" of the grain legume industry.

Their possibilities included:

- A breakthrough in reduction of world hunger.
- A transformation in eating habits and health.
- A transformation of the economy.
- A chain of pulse restaurants around Australia and New Zealand of course.
- A breakthrough in teamwork and ownership of the project promoting the worth of the grain legume industry.
- Promotion grain legume farming systems to environmental groups.

The vision worked, we now have a Departmental team with industry and project goals which I will return to later.

Further, it has rekindled my own grain legume drive after publishing a major report for the Australian Grain Legumes Research Council in March 1988 titled *Supply and Demand Trends, Price Relationships and the Market Potential for Selected Grain Legumes Grown in Australia.*

AREA AND PRODUCTION OF MAJOR WINTER GRAIN LEGUMES IN AUSTRALIA

The growth of the Australian grain legume industry since 1980 has been one of the fastest in the world, rivalled only by France which has had a spectacular increase in dry pea production. The winter grain legumes to be examined in this paper include lupins, field peas, chickpeas, faba beans and lentils (Table 1).

The area and production of Australian grain legumes exceeded 1 million ha and 1 million t (Table 1) respectively for the first time in 1986-87, when production reached 1.6 million t and the area sown was 1.3 million ha. The area sown in Australia rose by 355 % in the period 1982-83 to 1987-88. Production rose by 624 % during the same period.

However, a high plateau in the wool price and improved wheat prices in the last two years, coupled with grain legume prices which were both volatile and below farmers expectations, in 1988-89, has led to lower Australian lupin and field pea areas in 1989-90 relative to two years ago.

The chickpea area continues to expand from a negligible area in 1982-83 to 87,000 ha in 1989-90.

The faba bean area has declined because of disease problems whilst the lentil area is still very small.

The most significant production increases during the 1980's have been in dry pea (yellow) production in Victoria and South Australia, lupin production on the acid soils of Western Australia, and to a lesser extent, faba bean production in South Australia and more recently in Victoria.

Queensland is the dominant chickpea state but significant increases are occurring in Eastern and South Australia.

In the medium term the rapidly growing wool stockpile in Australia, the probability of a declining wheat price, the promise of a more competitive Australian dollar and the maintenance of relatively profitable prices could lead to further expansion in sowings of grain legumes. There is also a growing awareness of the value of grain legumes in dryland farming systems.

Table 1: The area, total production and average yield of winter grain legumes in Australia 1982-90.

Species	82/83	87/88	88/89	89/90
Area (10^3 ha)				
Chickpeas	-	55	70	87
Faba Beans	2	51	50	38
Field Peas	114	442	454	395
Lupins	257	1015	851	898
Production (kt).				
Chickpeas	-	54	89	94
Faba Beans	1	73	63	60
Field Peas	30	487	516	465
Lupins	199	855	933	838
Average yield (t/ha)				
Chickpeas	-	0.98	1.26	0.91
Faba Beans	-	1.43	1.25	1.34
Field Peas	0.27	1.10	1.14	1.24
Lupins	0.78	0.84	1.10	0.93

*Source: Australain Bureau of Agricultural and Resource Economics: *Commodity Statistical Bulletin - November 1987, Crop Report No. 57, 28 November 1989.*

TARGET MARKETS

In the major report three markets were identified as target markets for Australian grain legumes, these were India, the European Economic Community and Australia

There are also a number of niche markets for smaller quantities of specialist food legume varieties at premium prices and a number of other markets for large quantities of feed legumes but at lower prices than the three target markets.

INDIA

The recent lowering of the tariff from 35 % to 10 % on imported grain legumes has again emphasised the fine balance the Indian Government must pursue between keeping prices to the consumer down whilst at the same time encouraging local pulse production.

However, the policy of changing tariffs in either direction to suit political purposes is fraught with difficulty for international marketers trying to develop a consistent export market.

On December 5, Mr Singh, the new Indian Prime Minister announced:

1. A pledge to introduce radical reforms to benefit the country's farmers and poorer sections of the community.
2. At least half of the investment outlays should be channelled to rural areas.

Nevertheless, consumption of pulses in India is expected to double to around 25 million t by the year 2000. To maintain current (relatively low) per caput consumption levels, Indian yields would have to double which, given previous performance, is not likely.

Population growth is still a major problem in India. Although GDP per head is only $US300 a year, the

Indian economy is one of the fastest growing economies in the world with real GNP growing by 6 % a year. A continuation of this trend is likely to increase the demand for food legumes.

India produces and consumes many different types of grain legumes, but by far the most important is chickpeas. Indian chickpea production fell to 3.6 million t in 1988 due to drought (Table 2). This led to significant exports to India by Australia.

Table 2: Production of grain legumes by type: India: 1986-1988 (10^6 t).

	1986	1987	1988
Chickpeas	5.8	4.5	3.6
Dry beans	3.1	3.3	3.5
Dry peas	0.4	0.4	0.4
Lentils	0.7	0.7	0.7
Pigeon pea	2.4	2.1*	1.6*
Soya beans	0.9	1.0	1.4
Total	13.3	12.0	11.2

* estimate

Source: *FAO Production Yearbook 42, 1988; Directotate of Economics and Statistics: Ministry of Agriculture and Rural Development: New Delhi*

In 1986, total pulse imports by India from all destinations was 360,000 t. In 1988-89 Australia alone sent 99,000 t of whole peas worth $A27 million and 97,000 t of chickpeas valued at $A40 million. Pakistan and Bangladesh were also important chickpea outlets in the same year taking 43,000 t and 11,000 t respectively.

Under the current Indian import policy, importation of pulses is allowed under the open general licensing scheme subject only to Government tariff levels.

Future international trade will depend upon the relative prices of the various grain legumes (Table 3). The Australian dun pea is one of the cheapest and least liked pulses in India, and is used to partially substitute for more expensive chickpeas in the production of pea flour. Chickpeas, pigeon peas, mung beans and lentils are among the favoured legumes and are used as vegetables in prepared meals.

Prices of imported grain legumes reveal some significant price differences among legume types and range from $US236 /t for dun pea to $US541 /t for kabuli chickpeas (see Table 3).

These prices raise the issue of what legume should be grown in New Zealand and Australia to profitably take advantage of these market price discrepancies.

Table 3: Relative prices of imported pulses: India, 17 October 1989.

Legume grain	$US /t
Australian dun pea (yellow)	236
Chinese mung	310-315
Desi chana	348
Kabuli chickpea 29/30	541
Green mung	295
Hungarian white pea	288
Hungarian green pea	290
Turkish green split pea	337
U.S. No.1 green pea	320

Indian imports of pulses continue to rise. Trade data is available to 1987 and show import volumes rising from 307,000 t in 1985 to 418,000 t in 1987. In 1986 there were 186,000 t of dry bean imports, 74,000 t lentils, 30,000 t chickpea and 70,000 t other legumes. This figure is likely to increase significantly toward the year 2000.

THE EUROPEAN ECONOMIC COMMUNITY

The shortage of protein feed in the early 1970's and the United States embargo on soya bean exports prompted the community to change its regimes for protein feeds to increase its level of self-sufficiency. A policy of supporting the producer price of vegetable protein crops has led to a large increase in their production. At the same time supported European Community cereal prices have decreased the use of cereals in compound feeds in favour of other feedstuffs.

In 1988-89 the European Community-12 used 167 million t of commodities for animal feeding including 83 million t of cereal grain, 42 million t of cereal substitutes and 42 million t of protein products including 4.9 million t of grain legumes.

Low duties on imported non-grain feedstuffs such as grain legumes and manioc, have made these feedstuffs attractive to feed compounders, resulting in increased import volumes.

Table 4: Total European Community feed imports (10^3 t).

	1987	1989*
Feeds with high starch content		
Citrus pellets	1,652	1,700
Fruit residue	347	450
Maize germ meal	2,393	2,500
Molasses	3,467	3,200
Tapioca	6,986	6,700
Sugar beet pulp	553	700
Sweet potato	607	550
Wheat bran	242	250
Sub-total	14,818	14,400
Feeds with high protein content		
Copra meal	1,201	1,000
Corn gluten	4,707	4,700
Cotton seed meal	559	750
Dried distillers' grain	853	750
Feed peas	628	380
Fishmeal	885	790
Groundnut meal	248	350
Linseed meal	482	450
Lupins	320	150
Other oil meals	606	570
Palm kernel meal	1,028	1,100
Rapeseed meal	446	300
Soya bean meal	10,341	9,000
Sunflower seed meal	941	1,000
Sub-total	25,044	23,340
Total	39,862	37,740

* Estimate

Sources: *Eurostat; Nimexe; Statistics; Toepfer International*

In 1989, estimated European Community-12 feed imports totalled 37.7 million t including 14.4 million t of high starch feed, mainly tapioca, and 23.3 million t of high protein feed, mainly soya bean meal (Table 4).

Feed pea and lupin imports are relatively minor at 400,000 t and 150,000 t respectively. However, it is the volume and substitutability of products that counts.

Policies which support the producer price of meat, in combination with the availability of cheap feedstuffs, have contributed to increased livestock production, which has in turn increased the demand for livestock feed. However, livestock production in the European Community has stagnated at around 28 million t between 1987 and 1989.

In 1978 European Community support policies were introduced for the production of peas and beans (lupins were added in 1984). Production of peas has risen sharply. In 1982 pea production was 420,000 t. The estimate for 1989 is 3.3 million t (Table 5). Bean production was 780,000 t in 1982 in 1989 it was estimated to be 720,000 t. Lupin production in 1982 is very small (10,000 t).

The minimum producer price paid for peas in 1989 was $US288 /t and for beans it was $US267 /t.

Table 5: European Community grain legume production (kt).

Legume	1982	1987	1989
Peas	420	2,270	3,330
Beans	780	1,090	720

Source: *Agra Europe, November 17, 1989.*

A policy introduced in 1988 to reduce budgetary costs will indirectly help exporters to the European Economic Community. If a production limit of 3.5 million t of grain legumes (peas, beans and lupins) is exceeded, support prices will be reduced.

The major features of the support regime for peas, beans and lupins are a minimum grower price for producers and an incorporation aid subsidy for crushers who have paid growers this minimum price. The incorporation aid is intended to make European Community peas, beans and lupins competitive with protein feeds, such as soya bean meal, which are imported at world prices.

In the last three years Australian pea price values were worth in excess of 70% of the soya bean meal price because of the relatively high minimum produce prices paid for cereals in the European Community

The European Economic Community has recently introduced a security deposit scheme, for imports of peas and beans, of 40 ECU/t. The intention is to reduce fraud as European Economic Community crushers are alleged to be claiming an incorporation aid subsidy for imported peas and beans.

AUSTRALIA

The size of the Australian domestic stockfeed market had been rising rapidly in the last few years as increases in poultry and pig production and rising sheep and cattle numbers create more demand for alternative protein sources (Table 6).

Table 6: Australian livestock numbers 1983-1989 (10^6 head).

	83/84	86/87	88/89
Beef & Dairy Cattle	22.16	23.76	23.00
Sheep	135.10	153.20	161.70
Pigs	2.49	2.55	2.70
Poultry Slaughterings	231.20	276.50	295.00

Source: *Australian Bureau of Agricultural and Resource Economics.*

In recent years there has been a greater acceptance of grain legumes in stockfeed rations, particularly peas, and as a consequence, the relatively high price of wheat in 1988-89 and 1989-90 has led to up to 30% of peas being used in stockfeed rations for pigs and poultry.

For sheep and dairy cattle, lupins are cheaper and are perceived as being more easily digestible than for use in poultry and pigs.

The percentage of legume used in Australia will vary from year to year depending on the relative price of wheat and other cereals, meat meal, imported soya bean meal into southern Australia, oilseed meals from an April harvest in northern New South Wales and Queensland whereas the direction of use will also depend on the relative price of food legumes into India and imported soya bean meal into the European Economic Community.

NICHE MARKETS

Dry peas: It is clear that the European and Australian stockfeed markets are indifferent to the type of pea received other than paying a premium for low moisture peas. Premiums are paid for smooth white peas with consistent cotyledon colour for the splitting trade and for green peas to markets such as Columbia, Haiti, India, Peru, the Philippines and Venezuela but in competition with United States in particular.

The food market is not increasing in developed countries and whilst demand is increasing in the Indian sub-continent, peas are not a favoured legume, although green peas are at a premium to yellow peas in India. However, large stocks of green peas in the United States in recent years have led to a downturn in United States producer prices to below the price for yellow peas. There are niches for marrowfat peas into Asia and Europe, maple peas for bird seed and blue peas to developing countries.

Lupins: The hardness of the lupin seed coat reduces the digestibility of whole lupin seed in pig and poultry rations. Dehulling lupin seed to produce kernel meal is an attempt to increase the digestibility and utilize the high fibre of the seed coat but with limited success to date.

Lupins have won great acceptance in sheep and cattle rations and have a promising future in the aquaculture industry - perhaps for the developing New Zealand salmon industry.

Faba beans: There is a considerable demand for green immature beans which can be canned or quick frozen, particularly in the United Kingdom (known as Minden beans).

The beans can be used to produce high protein flour and are frequently used as a foodstuff in North Africa and other parts of the Middle East. Egypt, Italy and Saudi Arabia, have each purchased a ship load of faba beans from Australia in recent years.

There are also small markets for large seeded broad beans in the Middle East.

Chickpeas: Gram or chickpeas are the favourite grain legume of India, Pakistan and Bangladesh. The kabuli type grown mainly in Turkey is favoured around the Mediterranean rim. Turkey is the only major exporter. In 1989 Turkey had its worst drought for 30 years, the price of chickpeas rose to $US600 /t c.i.f. United Kingdom.

As with faba bean there are possible fresh pea markets for chickpeas.

Vetches: A new variety of vetch, Blanchefleur, has been developed which shows promise not only for livestock feed but as a high protein alternative winter food legume.

Lentils: There is only one major supplier of red cotyledon lentils in the world - Turkey. Canada and the United States concentrate on the production of green lentils. It is a significant market and is a suitable product for the soup, flour, snack, burger and sprout markets.

More product development work is required in the developed world to adopt grain legume products to higher income consumption patterns.

KEY MARKETING ISSUES FOR AUSTRALIA AND NEW ZEALAND

Market access: The stockfeed market for all winter grain legumes is beyond Australia and New Zealand's capacity to supply in the short to medium term provided the European Community market remains open. An issue which may upset this market is the payment by the European Community of an incorporation aid fee to include European Community cereals in their stockfeed rations.

Beyond the three target markets there are a number of newly emerging economies expanding their livestock sectors - Hong Kong, Korea, Malaysia, Singapore, Taiwan, Thailand - which could utilize grain legumes as a highly substitutable product for grain and protein ingredients.

Market systems: Highly volatile prices in the last two seasons due to the imposition of a 35% tariff by India; the United States and Canadian drought followed by a fall in soya bean prices due to a record Brazilian crop; an appreciation of the Australian currency and companies selling short leading to a sharp rise in price has upset farmers in terms of making price predictions and their ability to take a satisfactory market position.

The deregulation of the domestic Australian wheat market and the greater commercial flexibility offered to the Australian Wheat Board has led to the Board offering pool and cash prices for peas in Victoria and South Australia and a pool for lupins and faba beans in South Australia.

The Co-operative Bulk Handling Company in South Australia, which is a grower owned bulk handling co-operative, is offering warehouse facilities for grain legumes to farmers and end-users for a domestic fee ($A8.65 /t) and an additional fee if the crop is exported ($A4.45 /t).

Profitability of grain legume production: In deciding to grow a grain legume crop the farmer must decide on:

- where grain legumes fits into the farm rotation?

Grain legumes provide an excellent break crop from cereal disease, provide stubble grazing as well as being a profitable cash crop. Following cereal crops often give higher yields as a direct consequence of growing grain legumes.

- which grain legume to grow?

The advantage of growing peas is the availability of both the food and feed market. In Australia both faba beans and lupins are currently experiencing significant price discounts ($A15 and up to $A50 /t respectively) relative to peas.

Chick pea prices are at least $A100 /t higher than peas this year but they suffer some yield disadvantages relative to peas.

White and green peas offer a price premium but yield issues are again a factor.

Research and development: Marketing information, product specification or standards, product development, consumer research and product promotion are all issues currently being addressed by both national and state grain legume committees.

The choice of market for each crop, short term price information, food and feed standards, the development of new products for the domestic consumer and the promotion of those products are all critical for future expansion.

NATIONAL, STATE AND DEPARTMENTAL GRAIN LEGUME CONSULTATIVE COMMITTEES

To address the key marketing issues, state and national committees have been formed in Australia. At a national level representatives from all states - Grains Council, State Government, exporters, processors, co-operatives and the Grain Legumes Research Council - bring State issues forward for debate and endorsement by the national committee.

There is no funding for these bodies, but each of the major grain legumes is levied to pay for Grain Legumes Research Council research. The Department of Agriculture in South Australia is currently developing industry and program goals for the next three to five years. The department is heavily involved in grain legume production and market research with the national pea and lentil breeding programs, whilst the Waite Institute (Adelaide University) has a faba bean program.

THE FUTURE OF THE INDUSTRY

The development of the Australian grain legume industry during the 1980's, particularly in South Australia and Victoria, has given producers many more options for their farm commodity mix.

The benefits of crop rotations with grain legumes, prices received for cash crops and almost unlimited market potential has established the future of the industry on a permanent basis.

Given the current downturn in the fortunes of sheep and wool production it is likely that farmers in southern Australia will increase grain legume plantings in the medium term.

For New Zealand an immediate target would be to introduce peas to the stockfeed industry and eliminate most of the $NZ 7.3 million domestic imports of soya bean meal depending on the entry price of peas into computer feed rations for pigs and poultry.

A second target is to explore the possibility of producing full fat soya bean for stockfeed in the North Island and dry beans.

The availability of a large processing facility (Goodman Fielder Wattie) should ensure that a broader range of frozen and canned lines is grown which would create value added income for the New Zealand economy.

The expansion of seed multiplication services for Northern Hemisphere companies has potential.

GRAIN LEGUMES SOME NUTRITIONAL ASPECTS

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ABSTRACT

Various grain legume seeds are used as a major supplementary source of protein in many developing countries. The proximate composition of most of the grain legumes are quite similar, a common feature is their low concentration of fat. The protein quality of many legume seeds is affected by the presence of a number of anti-nutritive factors which may be reduced by suitable processing or cooking. The sprouting of legume seeds has received increased interest, particularly as an improvement in the nutritive value and palatabiltiy occurs during this process. Although legume seeds are widely used in the diets of millions of people, little research has been carried out on their nutritional quality as it relates to human nutrition. Strains should be identified which contain lower levels of anti-nutritive factors and selections should be made to find strains with reduced flatus potential. Selections of grain legumes should also be made to find strains containing elevated levels of the essential amino acid methionine. Increased consumption of legume seeds particularly in the sprouted form should be recommended for western-type diets as the fibre and the saponin content appears to have a beneficial effect on blood cholesterol levels. Lowered blood cholesterol levels would have a significant effect on the incidence of coronary heart disease in western countries.

INTRODUCTION

The death of a person before the age of 65 should be regarded as a considerable loss of economic and personal potential. Greater efforts should be made to consider the reasons for such early deaths. The data in Table 1 highlights some of the major causes of death in the age range 15 to 65 in the New Zealand population. A great deal of money is spent on the reduction of various forms of accidents. Smoking related causes of death e.g. lung cancer is also receiving a great deal of attention.

Deaths related to nutrition and eating habits for instance, colon cancer and coronary heart disease (CHD) have not received as much attention until recently. The main problem is the long term nature of the development of these diseases and the effect that genetic factors have on these nutritional related diseases.

One of the most interesting features of the health statistics in New Zealand is the gradual fall in the mortality rate due to coronary heart disease from 1968 to 1986. During this period, however, there has been a steady rise in both male and female colon cancer deaths each year.

A reasonable proportion of the deaths caused by colon cancer and CHD can be attributed to the average New Zealand diet which tends to contain high levels of saturated fat and low levels of dietary fibre.

Table 1: Selected causes of death in the whole New Zealand population in 1986 in the age range 15 to 65 (Department of Health, 1986).

	Men	Women	Total
Air accidents	18	4	22
Car accidents	485	141	626
Lung cancer	299	116	415
Colon cancer	112	223	335
Coronary heart disease	1,261	370	1,631
All other causes	2,384	1,635	4,023
Total all cases	4,559	2,493	7,052

The mortality data in Table 1 clearly shows that coronary heart disease accounts for 25 % of the deaths in New Zealand in the age group 15 - 65.

In countries were legumes are consumed to a greater extent e.g. Mexico and Egypt, the deaths due to heart disease are relatively low when compared to New Zealand or the United States (Table 2). It may be that this data is not really comparing like with like but it can be seen that in Egypt and Mexico for instance high death rates are caused by poor housing, sanitation and poor access to medical care. In Mexico 10 % of all deaths each year are due to gastro-enteritis, 10 % due to pneumonia. The leading causes of death in Egypt are bronchitis and asthma each causing 5 % of total deaths. Thus many people may die before they have the opportunity to develop coronary heart disease. It is unfortunate that there are no countries with a high standard of health care where high legume containing diets are consumed. It is interesting to note that some countries do not even report their basic statistics to the United Nations.

Table 2: Selected causes of death, rates per 100,000 people in each country (United Nations, 1982).

	Year	Coronary heart disease	Pneu-monia	Gastro-enter-itis
NZ males	1986	236	-	-
NZ females	1986	125	-	-
NZ males + females	1980	152	36	-
USA males + females	1978	288	24	0.8
Egypt males + females	1978	15	33	7
Mexico males + females	1978	22	61	60

The widely accepted theory as far as CHD is concerned is that high levels of saturated fat in western type diets lead to raised blood cholesterol. This, in turn, leads to atherosclerosis and an increased incidence of heart attacks (Carlson & Bottiger, 1972).

A number of studies indicate that legume seeds or their constituent proteins and fibre may lower serum cholesterol in both man and experimental animals (Jenkins *et al.*, 1983). Contrary to popular opinion dietary cholesterol contributes an average of no more than 10 % to serum cholesterol concentrations - therefore the association between dietary cholesterol and CHD is weak (Oliver, 1976).

One way to reduce the saturated fat and the cholesterol content of the diet is to recommend a reduction in ruminant meat, milk and milk related products in the diet. To do this effectively, it is best to recommend a realistic replacement in the diet. The addition of legumes to the diet are a reasonable way to reduce the overall fat content because of their generally low fat content (Table 3).

Table 3: Proximate composition of some selected legumes (g/100 g) (Savage, 1988; Savage & Deo, 1989a,b).

	Lentils	Peas	Mung beans
Crude protein	19-35	16-32	18-36
Oil	1-4	1-6	1-4
Crude fibre	1-6	1-10	0.4-13
Nitrogen free extract	52-70	57-74	60-72
Ash	2-6	2-4	2-5

PROXIMATE COMPOSITION

The proximate composition of legume seeds is quite consistent. The crude protein ranges from 15.6 % to 36.0 % which is, in general, superior to that found in cereals. Oil content is low, but generally the fatty acids are unsaturated. Legume seeds contain modest levels of crude fibre, the amount in foods depend on whether the seeds are dehusked prior to cooking. In the nitrogen free extract some interesting carbohydrates are found, these will be discussed later.

SAPONINS

Saponin content of many legume seeds is the most interesting positive feature (Table 4). These saponins are sterol or triterpene glycosides which are non-toxic, but have a characteristic bitter taste. Saponins in foods significantly reduce the plasma cholesterol concentrations of the animals consuming them (Oakenfull, 1981). Saponins appear to induce adsorption of bile acids onto dietary fibre in the intestine (Burkitt & Trowell, 1975), presumably due to their strong surface-active properties. Adsorption of bile acids onto dietary fibre will cause increased faecal loss of these bile acids (bile acids are normally re-absorbed further down the intestinal tract as part of the entero-hepatic circulation), which would be offset by increased conversion of liver cholesterol into bile acids which will tend to lower blood cholesterol levels.

Table 4: Saponins in some selected legume seeds (g/kg) (Savage, 1988; Savage & Deo, 1989a,b).

	Lentils	Field peas	Mung beans
Raw	3.7-4.6	1.1-2.5	5.7
Sprouted	-	-	27.0

An even more interesting observation (Table 4) is that during the process of sprouting mung beans, the saponin levels rise dramatically (Fenwick & Oakenfull, 1983).

MUNG BEAN SPROUTS

The Chinese have used mung bean sprouts for centuries and their wider use should be encouraged along with other sprouted legume seeds. During germination there is a significant increase in the vitamin C and folic acid content. At the same time there is a significant and useful reduction in the raffinose family of oligosaccharides, as these are used as a source of energy in the germination process. A feature of the raffinose family is that the individual mono-saccharides are α (1 $\rightarrow$ 6)-linked. This bond is not broken by mammalian digestive enzymes. Unfortunately anaerobic micro-organisms which normally inhabit the human colon, can degrade the raffinose family carbohydrates. Their metabolic activity leads to the generation of gas better known as flatus. The flatus potential of many legumes can be reduced by adequate soaking prior to cooking and rigorous autoclaving at 121 °C for 30 minutes.

The raffinose family of carbohydrates are one of the major negative features of legume seeds and research should be considered to reduce their levels in new cultivars.

The most interesting feature of mung bean sprouts is that the protein of germinated mung bean seeds is more digestible than the raw seed (Venkataraman *et al.*, 1976; Savage & Griffiths, 1988). The biological value is however, unchanged. During germination little change occurs in the amino acid content of mung beans, the main effect is the reduction of between 85 and 88 % of the trypsin inhibitor levels (Kamalakannan *et al.*, 1981; Chitra & Sadasivam, 1986).

TRYPSIN INHIBITORS

Trypsin inhibitors in seeds bind with the enzymes secreted by the pancreas such as trypsin and chymotrypsin. These digestive enzymes then cannot break down food protein. An animal's response is to secrete further trypsin and chymotrypsin which causes hypertrophy of the pancreas. It is interesting to note that these pancreatic enzymes are particularly rich in sulphur containing amino acids and this process of the additional secretion of digestive enzymes will result in a drain of these particular amino acids. This can lead to an imbalance of amino acids in the body which will be followed by increased protein catabolism. This effect is accentuated due to the fact that legume seed protein characteristically contains low levels of the sulphur containing amino acids, methionine and cysteine.

An interesting feature of the trypsin inhibitor content is that while it is easily degraded during germination of the seed (Savage & Deo, 1989) it is particularly resistant to destruction on heating. Autoclaving for 30 min at 121 °C is completely effective at destroying all the inhibitor in mung beans, while cooking at 100 °C for 60 minutes only destroys approximately 50 % of the inhibitor (Sohonie & Bhandarkar, 1955).

PROTEIN

A consistent feature of the amino acid content of legume protein is the low level of the essential amino acid methionine. From Table 5 it can be seen that some variation in this amino acid occurs between different legume seeds. These mean values hide a considerable variation in values reported in the literature (Savage, 1988; Savage and Deo, 1989a,b). This would suggest that simple selection could be used to good effect to improve the methionine content of the protein of many of the common legumes.

A considerable improvement in the protein quality of peas would occur if the legumin fraction which contains a higher sulphur amino acid content, was increased or the vicilin content was reduced. The albumin fraction in peas also has a more favourable amino acid profile and recent experiments have shown that some variation in this protein fraction does occur in cultivars already in use. Some potential for modifying the quality of peas already exists and this type of approach could easily be applied to other legume seeds.

Table 5: **Some important amino acids of legume flours (g/100 g of total amino acids). (Recalculated from Sosulski, 1983).**

Amino acid	Lentil	Field pea	Navy bean	Soya bean	Lima bean
Arginine	7.7	8.1	6.4	7.5	5.5
Cysteine	1.0	1.5	0.8	1.1	1.0
Histidine	2.4	2.4	3.2	2.2	3.0
Isoleucine	4.7	4.3	4.6	4.8	5.1
Leucine	7.8	7.4	8.4	7.6	8.7
Lysine	7.8	7.7	7.2	6.5	6.7
Methionine	0.8	0.9	1.2	1.4	1.2
Phenylalanine	5.1	4.6	5.5	5.0	6.1
Threonine	3.7	3.9	4.0	3.8	4.2
Tryptophan	1.0	1.0	1.0	1.3	1.3
Tyrosine	3.6	2.9	3.0	3.5	3.0
Valine	5.2	4.8	5.2	5.0	5.5

CARBOHYDRATES

The unusual carbohydrate content of legume seeds is the feature which most often appears to limit their wider acceptance in human foods. The raffinose family of carbohydrates (raffinose, stachyose and verbascose) are readily fermented in the hind gut. As mentioned before the levels are reduced on germination of the seed or by rigorous cooking. The data summarised in Table 6 suggests that a considerable variation in the concentration of these undesirable carbohydrates does already exist and a careful breeding programme could select less gas producing cultivars.

Legumes generally contain useful amounts of water insoluble carbohydrates (dietary fibre) which have a generally beneficial effect in the gastro-intestinal tract. Thomas *et al.* (1986) has shown that mung bean fibre also binds to bile acids in the small intestine of rats resulting in lowered cholesterol, LDL and VLDL fractions in the serum. The amount of fibre in the cooked food depends very much on whether the seed is dehusked prior to cooking. A large proportion of the fibre is contained in the testa (husk).

The testa of many legumes also contains significant amounts of tannins and phenolic acid which tend to react with the α-amino group of lysine in the protein and polymerise into tannin-protein complexes which are resistant to monogastric digestive enzymes (Sosulski, 1979). Since most of the tannins (81-85 %) are contained in the testa (Barroga *et al.*, 1985), a practical way to improve the nutritional value of the seeds is to dehusk the seed before cooking unfortunately this will involve the loss of the advantages of the fibre content of the testa. In general the darker coloured seed coats of mung beans contain higher levels of tannins (Barroga *et al.*, 1985). While Price *et al.* (1980) have shown that green pea seed coats contain no tannins presumably as a result of extensive selection of low tannin cultivars. It is interesting to note that if these polyphenolic compounds are absorbed by mammals, detoxification in the liver involves methylation which would put a further requirement on the limited methionine content of diets based on legume seed protein.

Table 6: **Carbohydrate composition of some selected legumes (g/kg) (Savage, 1988; Savage & Deo, 1989a,b).**

	Lentils	Peas	Mung beans
Raffinose	3-10	3-16	3-26
Stachyose	14-27	22-55	5-28
Verbascose	1-31	21-28	17-38
Total available carbohydrates	426-625	667	456-630
Acid detergent fibre	50-56	78	57
Neutral detergent fibre	97	58-163	71-81

SUMMARY

A breeding programme that concentrated on the reduction of the trypsin inhibitor content of legume seed protein combined with even a modest increase in the methionine content of the seed protein would have a dramatic effect on the nutritional value of legumes for both human and animal use.

A reduction in the raffinose family of carbohydrates would also improve the acceptability of many legume seeds.

The main problem with legume seeds in their use in human diets is the time needed to process them (both soaking and cooking). This makes them an unpopular food for the modern house-person. To improve their use in this modern world, industry needs to present legume seeds processed and cooked-much like the well loved baked bean.

Sprouted legumes are making a reasonable impact on our diets as they are being presented ready to use. Their further use should be encouraged because of their improved nutritional characteristics and useful effect of lowering blood cholesterol. Legume seeds need to be processed and presented as interesting and healthy foods. They need to be better presented.

If we could encourage an increased consumption of legume seeds linked with a reduction in total fat intake and a move towards the consumption of more polyunsaturated fats I believe it would be possible to change the cause of death and the life expectancy in the New Zealand population. This effect, however, would take some time to show in our health (or disease) statistics.

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GRAIN LEGUMES IN THE HUMAN DIET

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ABSTRACT

Although they have traditionally had limited use in the New Zealand diet, legumes have a very long agricultural history. Today they are still a vital source of protein in many regions and are a traditional food item in Europe and in the Mediterranean. As a staple food, they make a significant nutritional contribution to the diet. From a nutritional perspective, legumes are high in protein and low in fat and reflect the current nutrition guidelines for all New Zealanders, which are to eat a diet lower in fat and containing less animal protein. Legumes are also high in fibre, a nutrient lacking in many New Zealanders' diets, yet essential for health.

Additional Key Words: Glycaemic index, nutritional value, recipes

PROTEIN

The average New Zealander often eats 50 - 100 % more protein than their bodies can utilize - usually in the form of meat.

Legumes do have deficiencies in their amino acid profile which make them generally less usable by the body than animal protein. However, these amino acid deficiencies can be matched with the amino acid strengths in other plant foods to provide protein of good biological value. This matching is called 'protein complementarity'.

For example, when beans and wheat are eaten together, their respective amino acid deficiencies are supplemented by the surplus amounts present in the other seed. For example the lack of lysine in the cereal is supplemented by the beans and the lack of methionine in the beans is supplemented by the wheat, thus the biological value of the protein of the two seeds is increased. (Figure 1).

FATS

Legumes provide protein without fat, unlike animal protein. The National Heart Foundation is encouraging New Zealanders to reduce their fat intake, especially animal fat to 35 % of total energy intake, and to reduce it to 30 % of total energy by the year 2000.

The 1980 National Dietary survey showed that 41 % of daily energy comes from fat alone. A 10 - 15 % reduction in fat consumption is a major dietary behavioural change. The inclusion of legumes to partially replace meat as a source of low fat protein in the diet would facilitate this change.

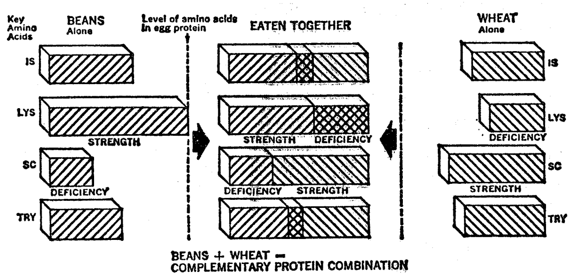

Figure 1.The amino acids from beans and wheat complement each other (from FAO, 1970)

CARBOHYDRATES

Beans are a rich source of complex fibrous carbohydrates. New Zealanders are being encouraged to eat more complex carbohydrate. In dietetic practice legumes are referred to as lente carbohydrates or carbohydrates with a low glycaemic index.

Glycaemic Index:

$$GI = \frac{\text{blood glucose test food} \times 100}{\text{blood glucose of reference. food}}$$

The glycaemic index study of 78 individual foods demonstrates the lower glycaemic index of legumes (Figure 2)(Thorburn *et al.*, 1986).

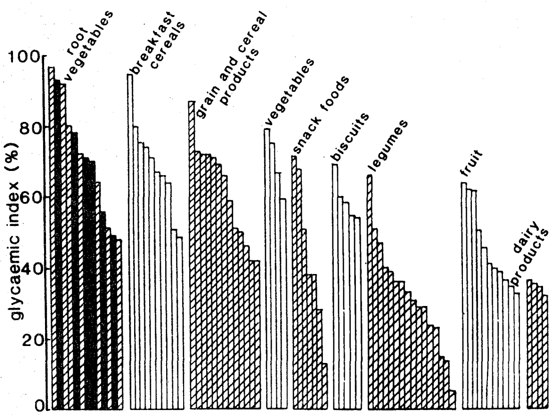

Figure 2.The glycaemic index of 78 individual foods. (From Thorburn *et al.*, 1986).

Diets high in complex carbohydrate which emphasise those foods with a low glycaemic index but low in fat, significantly improve glycaemic and metabolic control in the management of diabetes mellitus a disorder affecting approximately 5 % of New Zealanders.

FIBRE

Legumes are particularly rich in dietary fibre. Dietary fibres can be classified by their solubility in water, since water soluble and water insoluble fibres have distinct physiological effects.

Water solubility of fibres

Insoluble fibre (Structural)
- Lignin
- Cellulose
- Some hemicelluloses

Soluble fibre (gel forming)
- Pectins
- Gums
- Mucilages
- Remaining hemicelluloses

Most foods of plant origin contain both soluble and insoluble fibres, but they tend to be rich in either one or the other. Citrus fruits, oats, barley and legumes contain more soluble fibre. Oats and beans, as opposed to lentils and peas, are especially good sources of gums - gel forming fibres.

The consumption of diets rich in plant foods is inversely related to the incidence of a variety of life-style related disorders.

Physiological effects of soluble fibre

1. Increased viscosity of the stomach contents.
2. Delayed gastric emptying.
3. Slower rate of digestion and absorption of nutrients in the upper intestinal tract.
4. Decreased intra-luminal colonic pressure.
5. Increased stool volume and weight.
6. Increased production of volatile fatty-acids.
7. Altered bile salt metabolism.

The effect of delayed gastric emptying may assist with control of body weight, since an increased feeling of fullness promotes satiety. Diets high in soluble fibre lower serum insulin, enhancing satiety, since insulin stimulates appetite. The slower rate of digestion and absorption of nutrients slows absorption of glucose from the intestinal tract, improving glycaemic control in diabetes.

Constipation is a major problem in developed countries, including New Zealand, contributing to haeomorrhoids, varicose veins and diverticular disease of the colon. Dietary fibre is hygroscopic and softens the stools, resulting in decreased intraluminal pressure and increased stool volume and weight. Soluble fibre when combined with cellulose fibre has a superior bulk forming effect for promoting normal laxation.

The anticarcinogenic effect of fibre is currently under close scrutiny, as the role of fat and fibre has not been clearly defined. However fibre can bind carcinogens by its hygroscopic effect.

Raised serum cholesterol is a major risk factor for heart disease. Soluble fibre lowers cholesterol levels by binding with bile salts and other blood fats resulting in a reduction in the quantity of cholesterol absorbed by the intestinal mucosa. Resulting in an increased excretion of bile salts in the faeces.

Soluble fibre is fermented by the colonic bacteria to form gases and short chain fatty acids. The latter are almost completely absorbed by the portal vein which may mediate changes in glucose and lipid metabolism.

Current guidelines recommend 20 g of dietary fibre per 1000 K calories. Individuals with diabetes mellitus and those with high cholesterol levels are encouraged to consume nearly half their fibre intake as soluble fibre.

The 1980 National Dietary Survey showed that many New Zealanders need to double, or treble, their intake of dietary fibre, not by adding fibre concentrates but by increasing their intake of complex carbohydrates through the consumption of legumes, fruit, vegetables, whole grain cereals and bread.

The fibre content of cooked legumes per serving is superior to most other complex carbohydrate foods. For example:-

Foods containing 2.0 g Fibre:

1 thin slice bread (90 % whole meal)
4 thin slices bread (white)
1/2 cup porridge
2/3 cup kornies
1 apple
1 1/2 tablespoons of baked beans
1/4 cup lentils

Unless beans are regularly included in the diet it is difficult to reach the recommendation for fibre intake - especially soluble fibre.

Economically, partial substitution of meat with legumes is attractive when the price of New Zealand beef has nearly doubled in recent times (Table 1).

When considering the nutrient needs of an average adult male in a semi-sedentary occupation, 250 g of rump steak exceeds the total daily protein requirement, the fat content represents nearly half the recommended daily intake (30 % of total energy) and supplies 25 % of the recommended daily energy intake.

The beef and bean goulash, by comparison, is significantly lower in fat, provides approximately half the daily protein intake and more than half the recommended fibre intake, especially soluble fibre. This recipe is suitable for inclusion in diets for the weight conscious or the individual with diabetes mellitus or elevated blood cholesterol levels.

From a nutritional perspective, grain legumes in the human diet complement the New Zealand nutrition guidelines - to eat a diet higher in complex- fibre containing carbohydrates, low in fat and with less emphasis on animal protein. However, grain legumes are not indigenous to the New Zealand diet and they continue to be used in a relatively limited way. The question remains - how can New Zealanders be encouraged to include beans in their everyday eating habits?

Table 1. Comparative cost and nutritive value of 250 g serve of beef and bean goulash compared with fried rump steak.

	Beef and bean goulash	Rump Steak, (fried)
Cost	$1.90	$3.40
Protein	27.0 g	71.5 g
Carbohydrate	40.0 g	0.0 g
Fat	8.0 g	36.5 g
Fibre	16.0 g	0.0 g
K calories	340	615

Barriers to acceptance exist and the task for food growers, manufacturers and retailers is to find ways of overcoming these barriers by appropriate marketing and promotion, and for Dietitians and other food experts to educate the consumer regarding the preparation, cooking and serving of legumes.

INCORPORATION INTO MEALS

When a traditional menu sequence is employed, it appears simple to incorporate grain legumes into the New Zealand diet. Pates, purees, and roasted whole legumes can be used as appetisers and pre-meal nibbles or snacks.

Soups can be light-weight adjuncts to a meal, or a meal in themselves, especially when teamed with bread or another grain cereal product.

The theme of a meal-in-a-cup demonstrates the concept of serving legumes or nuts and cereals together at a meal in order to achieve a complementary mixture of essential amino acids. Complementarity is not difficult to achieve, but its importance in terms of adequate nutrition needs to be promoted. So, when educating the consumer in this concept, we should begin with what people are already doing to put complementarity into action. Baked beans on whole meal toast, or the peanut butter whole meal bread sandwich, are examples which New Zealanders already employ.

Grain legumes can be teamed with meat. Cassoulet, a classic dish of France is a hearty stew of fresh and preserved meats, beans, herbs and tomatoes, which is blended by slow cooking into a satisfying and inexpensive use of small amounts of meat.

Across the other side of the globe, Mexican beans are a traditional dish which can be recycled into another meal as refried beans. The latter can be served as an appetiser or as a main meal, with accompaniments such as salad, and tortilla.

The use of grain legumes does not need to be restricted to the classic dishes of other cultures. A pie crust can be filled with a mixture of red beans and vegetables, bound in a savoury custard.

Lentils require only a short cooking time in order to be reduced to a paste or puree. In this form they can be shaped into patties for pan-cooking or made into the lentil version of a meat loaf. They can also be incorporated into stuffings, dips and spreads for bread or crackers - hummus is one example.

Grain legumes in salads, in both the cooked bean and sprouted form are becoming more popular in New Zealand.

GENERAL NUTRITIONAL VALUE

Grain legumes are inexpensive, compact and easily stored. They are a rich source of all vitamins, with the exception of Vitamin C and B12 and are a useful source of nutrients such as calcium, iron and other trace elements.

Sprouted beans have other desirable nutrition properties which are different to those of the original legume, such as a higher Vitamin C content, high water content (therefore lower in calories).

High fibre diets are associated with decreased absorption of iron, calcium, zinc and other trace elements.

The current recommendations to increase dietary fibre would not be expected to be high enough to have any significant effect on mineral absorption, providing an adequate intake of the minerals in question is maintained. While fibre may bind with minerals in the duodenum and ileum, there is release of some ions in the large bowel possibly due to the fermentation of soluble fibre. However, it is important to still include meat in the diet, despite the quest to consume more legumes, as meat is still the most important source of iron, zinc and vitamin B12. The serving of a Vitamin C rich fruit or vegetable at the same meal will ensure the optimal uptake of iron from grain legumes.

BARRIERS TO LEGUME USE

Barriers currently exist to the acceptance of grain legumes by the average New Zealander.

1. Understanding of the uses of grain legumes has been lost to New Zealand during Colonial and post-Colonial times. The ability of farmers to produce cheap meat, a food which has a high consumer appeal, means that New Zealanders as a group have not been required to extend or supplement a limited meat supply with grain legumes.
2. The image which the average New Zealander has of legumes is that they are time consuming to cook, are visually unattractive and are generally tasteless, boring and antisocial.
3. As the range of convenience foods increases consumers expect to spend less time in food preparation and service and are unlikely to adopt a food which requires lengthy preparation and cooking.

OVERCOMING BARRIERS

Education

1. Consumers can be informed of the uses to which grain legumes are already being put in the New Zealand menu. Many people are unaware that the meal of baked beans served with bread, plays the same role as more exotic mixtures of grain legumes and cereals.
2. Consumers can be informed of quick and easy ways to achieve the initial cooking of grain legumes, especially those which retain their shape after cooking. These can be frozen once cooked and incorporated into a dish when required.
3. Consumers can be made aware of safe ways of handling grain legumes. The dangers of eating incompletely cooked or soaked, uncooked beans, must be stressed. Consumers need to be made aware that the low acidity content of cooked legumes and lentils makes them vulnerable to bacterial contamination. The same precautions which apply

to meat dishes of covering and refrigeration of cooked beans, or adequate heating before serving, must be observed.

Promotion

In the current health promotion and economic climate an effective marketing and information package could motivate consumers to use grain legumes more freely. Legume cookery can be colourful and varied as a multiplicity of legumes are available.

The creative use of herbs, spices and other condiments adds to their colour and flavour. Three condiments are noted as being especially appropriate for use in legume cookery - dried avocado leaves, fresh coriander and dried oregano, because they are traditionally believed to relieve the digestive side effects of eating legume dishes.

Ways of incorporating grain legumes into staple food items in this country needs to be researched. The use of legume and lentil flour to augment standard bread flours has not been widely promoted in New Zealand, with the exception of a bread enriched with soya meal recently released on to the market.

There needs to be a creative broadening of the basis on which grain legumes can be included in modern eating patterns. Creative solutions need to be found to raise legumes to the status of ready-to-eat, convenience food. However, it will be important to develop products which retain the nutritional qualities of grain legumes as a desired addition to the New Zealand diet. In other words, products would ideally retain some, if not all of the low fat, high fibre qualities of the original legume.

Legume convenience foods exist in other cultures and are beginning to be incorporated into our own diets. Commercially prepared bean sprouts, soya flour and bean curd are three of these. Different legumes, in the form of bean sprouts, have distinctive flavour and texture and can be promoted as snack foods.

CONCLUSION

There is a place for grain legumes in the New Zealand diet, both for reasons of health and of economy. An active educational and promotional campaign which addresses some of the issues raised in this paper may go some way towards raising the profile of grain legumes in this country.

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EXAMPLES OF LEGUME BASED RECIPES FOR EVALUATION

Dried red lentils were ground finely in an electric coffee/spice grinder and used in place of 10 % of the standard white flour required in the following recipes.

BASIC BREAD

(modified from *The New Zealand Bread Book.*, Browne, *et al.* (1981)).

Ingredients:

600 ml warm water
1 kg white flour
1 T dried yeast
1 T salt
1 T sugar
1 T melted butter or margarine

Method:

1. Add dried yeast and sugar to warm water and leave in a warm place while other ingredients are being prepared.
2. Sift flour and salt together.
3. Add most of the melted butter to yeast and water mixture. Use the rest of the butter to grease the bowl, the top of the dough and the baking tins.
4. Tip most of the flour into the liquid ingredients and stir with a wooden spoon until the mixture becomes too stiff to continue. Use your hands to form the dough.
5. Knead the dough for 7 - 10 minutes on a board, lightly floured with the extra dry ingredients.
6. Place the dough in a greased, lightly greasing the top of the dough with butter.
7. Cover the bowl and leave in a warm place to rest for 15 minutes.
8. Knead the dough lightly, and divide into pieces.
9. Shape as required and place in lightly greased containers.
10. Brush the top of each piece of dough of dough with butter, cover with plastic film, and leave in a warm place to double in size (30 - 60 minutes).
11. Bake in a hot oven 220° C to 230° C for 30 - 35 minutes or 15 - 20 minutes for bread loaves.

A variation which used 10 % red lentil flour did not require modification of the basic ingredients, the method, the cooking times or the temperature.

The amount of dough in this recipe will produce 2 x 500 g loaves or 20 x 80 g bread rolls.

DROPPED COOKIES

(From *The Basic Cook Book*, Heseltine & Dow (1935))

Ingredients:

1/2 C butter or other fat
1/2 t vanilla
1 C sugar
2 C flour
1 egg, unbeaten
1/4 t salt
4 T milk
2 t baking powder

Method:

1. Soften butter in a bowl, add sugar, milk, and flavouring and stir thoroughly.
2. Sift flour, baking powder and salt together and stir into mixture in the bowl.
3. Push from a teaspoon onto a well-greased cooking tray.
4. Bake on top shelf in a moderate oven (180° C-200° C) until firm to the touch and delicately brown in colour (8 - 12 minutes).

A variation which used 10 % red lentil flour did not require any alteration to the recipe.

An acceptable variation was to use of 1/4 C each of peanut butter and butter instead of the 1/2 C butter stated along with the 10 % red lentil flour.

HUMMUS

Ingredients:

1.5 C cooked chick peas
2 T tahini (sesame butter) or 2 T sesame seeds and 100 ml plain yoghurt
Juice of 1 lemon
Garlic to taste

Method:

Blend all the ingredients together in a food processor until smooth.

THE INCLUSION OF LENTIL FLOUR IN BREAD

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ABSTRACT

Lentils are a good source of protein, carbohydrate, fibre, soluble fibre, and B vitamins. They contain low levels of fat, cholesterol and sodium - factors associated with cardiovascular disease. Lentils provide slowly absorbed carbohydrate which causes a flatter blood glucose profile even in non-insulin dependent *diabetes mellitus*. All of these factors make lentils a desirable addition to the New Zealand diet.

The main barrier to including lentils in our diet is finding an attractive way to present them. The inclusion of lentil flour in bread is one way to introduce lentils into the diet and this product was tested on a panel of consumers. It was found that although the lentil flour bread was easily distinguishable from plain flour bread, the former was quite acceptable to the panel.

Additional Key Words: *lentil flour, bread, fibre,* diabetes mellitus, *acceptability, colorimetry.*

INTRODUCTION

Lentils are a good source of easily available, cheap protein which can complement cereal protein for several essential amino acids (Savage, 1988). They have a considerable part to play in combating the protein-calorie deficiency conditions which occur in some countries. In many of the developing countries lentils are consumed as dahl mixed with other foods.

Lentils, apart from being a good source of protein, contain useful amounts of fibre, soluble fibre, potassium and B vitamins. They contain low levels of fat, cholesterol and sodium. These factors appear to protect cardiovascular health. Lentils provide slowly absorbed carbohydrate which gives a flatter blood glucose profile even in non-insulin dependent *diabetes mellitus* (Thorburn *et al.*, 1986). This 'slow release' property of lentils is heat labile which suggests that antinutrients or enzyme inhibitors are inducing this effect. Similar studies by Anderson & Ward (1979), Simpson *et al.* (1981) and Jenkins *et al.* (1984) have also shown the value of increased lentil or legume content in the diet of certain diabetic patients owing to the reduced rate of carbohydrate digestion. These features of lentils make them a desirable adjunct in human diets as they may provide a protective factor against the early onset of lifestyle diseases common in New Zealand and in other developed countries.

Jenkins *et al.* (1980) suggest that a change of diet to include higher proportions of lentils (partially replacing meat) would allow a higher carbohydrate diet to be eaten with a reduction in fat intake. Such changes would give lower fasting serum cholesterol concentrations and post-prandial blood glucose values. These changes may help reduce morbidity and mortality both from diabetes and arterial disease, towards levels seen in countries where more slow- release carbohydrates are eaten.

The main problem with the inclusion of lentils in New Zealand diets is to find an attractive way of presenting them. Some interesting cook books have been compiled and a New Zealand booklet containing a wide range of lentil dishes has recently been published (Hills *et al.*, 1983). The use of lentils in western diets is undoubtedly restricted by the time needed to process them (both soaking and cooking). One way to encourage their increased usage is to present them in a fully processed form much in the way navy beans are cooked, mixed with tomato sauce and canned to provide baked beans. Baked beans only need to be reheated to quickly provide a nutritious meal.

The inclusion of lentil flour in bread would increase the protein content and provide a useful method of including lentils in the diet of people requiring it for nutritional reasons. The inclusion of lentil flour in bread would also provide a non-obvious method of increasing lentil consumption in the diet. In addition it would provide bakers with another speciality product which may increase overall consumption of bread.

The use of composite flour in bread making has received some attention in the past few years. The addition of legume flours (e.g., soya bean) improves the nutritional value of bread not only because of its higher protein content but also because of its higher lysine content compared with wheat flour. D'Appolonia (1977) showed that flour prepared from a range of legumes including lentils could be successfully incorporated into bread. Indeed, bread containing 5 to 10 % legume flour showed a whiter crumb colour when compared with the whole-wheat loaf. D'Appolonia (1977) suggested that a lipoxygenase enzyme in the legume flour was responsible for the improved effect on crumb colour. This is interesting as lentil flours have a yellow or brown appearance. The addition of 10 % lentil resulted in a bread that had a pleasant taste and aroma appreciated by 67 % of the test panel (D'Appolonia, 1977).

The object of this experiment was to investigate the inclusion of finely ground lentil flour in traditionally baked wheat flour bread. It was proposed to investigate whether the inclusion of up to 10 % lentil flour in bread was acceptable according to a number of organoleptic measurements.

METHODS

Two types of bread were baked using a basic bread recipe (Browne *et al.*, 1981). New Zealand grown dried red lentils (cultivar Titore) were finely ground in an electric coffee mill and used in place of 10 % of the standard white flour in the basic bread recipe. Each sample of dough was processed and baked in the same way. Two 500 g loaves were made for both the white and lentil flour bread.

Proximate analysis: Moisture, ash, crude fibre and protein content was determined by standard AOAC Methods (1980).

Acceptability experiment: On the day of the experiment each sample of bread was cut into 10 mm slices and then cut into 30 x 30 mm squares. Three samples (labelled A, B or C) were placed on a paper plate and were accompanied by a questionnaire. Two of the samples were the plain white bread while the third sample was the lentil bread. Thirty eight participants of the legume conference were invited to taste each sample of bread in this triangle test and fill in their observations on the questionnaire. This triangle test evaluation was carried out in the same well lit room; none of the participants were aware which of the samples was the lentil bread. None of the participants had eaten or drunk anything for 3 hours before the evaluations. The participants were asked to score the attributes (Table 2) of each bread sample using a score from 1 to 5 according to the following: for the attributes appearance, aroma, colour, texture, flavour the score was from 1 (like) to 5 (dislike); for sweetness the score was 1 (not sweet) to 5 (very sweet); for saltiness the score was 1 (no salt) to 5 (too much salt); and for palate the score was 1 (bland) to 5 (bitter).

Colorimetry: Colorimetry was carried out on a Hunterlab Labscan spectrocolorimeter LS 5000 (Hunterlab Associates Laboratory Inc. Reston, Virginia, USA.) using illuminant D65 (Yn=100, Xn=94.83, Zn=107.38, Ka=172.1 Kb=66.7) 10 degree illumination standard observer through a 3 cm illumination port. Tristimulus XYZ, Lab and CIE (1976) $L^*a^*b^*$ values were measured such that, lightness $L^* = 116(Y/Yn)^{1/3}-16$, red-green chromaticness $a^* = 500[(X/Xn)^{1/3}-(Y/Yn)^{1/3}]$, yellow-blue chromaticness $b^* = 200[(Y/Yn)^{1/3}-(Z/Zn)^{1/3}]$. The colorimeter was calibrated against a white tile (White LS-12118) which gave the following values: X 81.01, Y 86.69, Z 87.96.

Colorimetric measurements were made on freshly cut portions of each sample of bread. Four readings were taken of each sample (Table 4) with the sample being rotated through 90 ° after each reading.

Statistical analysis: The forms were coded and the attribute scores analysed using analysis of variance for a two factor design, the factors being subjects, and flour types.

RESULTS

The proximate composition of the two samples of bread was very similar (Table 1) except that the protein content of the lentil bread was 7 % higher than the plain flour bread. This resulted from the substitution of the higher protein lentils for wheat flour in the lentil bread.

A preliminary review of the anonymous comments on the forms suggested that the lentil bread was well liked. Mean data of the attributes evaluated for each bread sample are summarised in Table 2. Analysis of variance for each attribute shows that only for sweet taste was there any significant difference between the two breads (P < 0.01). Lentil bread was thought to be less sweet than plain flour bread. Figure 1 shows a profile of the mean attribute score for each bread for each of the parameters the tasters were asked to evaluate.

Table 1. Proximate composition of each bread

(g/100 as consumed)	Plain Flour	Lentil Flour
Moisture	46.71	45.07
Ash	1.25	1.29
Protein	7.40	7.91
Fat	0.37	0.54
Crude Fibre	0.34	0.34

Table 2. Mean values for the attribute scores for each bread.

Attribute	Plain flour	Lentil flour	SED
Appearance	2.53	2.81	0.19
Aroma	2.42	2.72	0.17
Colour	2.50	2.45	0.17
Texture	2.47	2.78	0.20
Flavour	2.54	2.43	0.17
Sweetness	3.26	3.61	0.13**
Saltiness	2.51	2.44	0.11
Palate	2.24	2.44	0.13

** Significant P <0.01

Table 3 shows that equal numbers of observers preferred the plain flour and lentil breads. Twenty two (58 %) of the 38 participants correctly identified the lentil bread while 10 were unable to make a choice and 6 made an incorrect choice.

The lentil bread appeared to have an orange cast which resulted from the inclusion of lentil flour prepared from cultivar Titore which has a distinctive orange/red hue. The colorimeter could detect significant differences between the colour of the two samples of breads (Table 4) but this difference in colour was not disliked by the tasters (Table 2).

Table 3. Preferences for each sample and detectability of lentil flour

	Preferences	Detection
Plain bread (sample 1)	11	2
Plain bread (sample 2)	6	4
Lentil bread (sample 3)	16	22
No answer	5	10

CONCLUSIONS

From this experiment it is clear that bread made from flour supplemented with finely ground lentil can easily be detected. However, given that people can identify the bread there does not seem to be any aversion to it, and preferences seem to be evenly divided between plain flour and lentil flour bread.

Bread made from lentil flour had a reasonably distinctive orange cast derived from the lentil cultivar Titore. This result is in contrast to the observations of D'Appolonia (1977) who stated that bread baked with 5 or 10 % lentil flour showed a whiter crumb colour compared to the control loaf. D'Appolonia observed that the original lentil flour in his experiment had a yellow colour which suggests that cultivar Laird might have been used in his experiments. Laird is a Canadian lentil cultivar and is widely grown in that country.

Up to 10 % finely ground lentil flour can be added to wheat flour to make a nutritious and interesting loaf. The lentil flour loaf had a distinctive and interesting colour and a taste that was widely appreciated. The results from this preliminary experiment suggest that speciality loaves containing lentil flour may be of some interest to the consumer. The use of lentil containing bread would therefore increase the amount of legumes consumed in the diet without making any major changes to eating habits.

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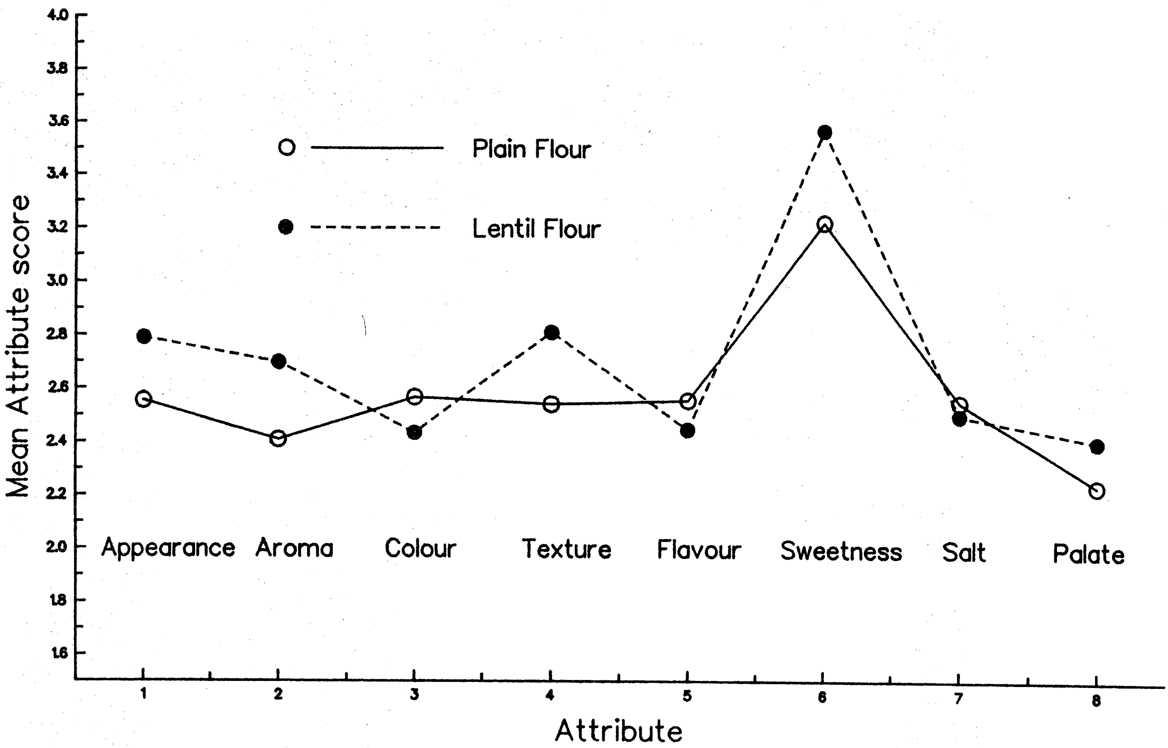

Figure 1. Attribute profile of plain and lentil bread.

Table 4. Mean values and standard deviation for colorimetric measurements of each sample of bread

Method of colour Determination		White bread Mean	White bread S.D.	Lentil bread Mean	Lentil bread S.D.	Significance (P)
Tristimulus	X	44.04	0.63	37.85	0.67	< 0.001
	Y	46.74	1.29	39.58	0.68	< 0.001
	Z	33.06	0.44	26.33	0.35	< 0.001
Lab	L	68.36	0.93	62.92	0.55	< 0.001
	a	0.62	0.28	0.94	0.07	N.S.
	b	15.55	0.78	15.95	0.24	N.S.
CIE	L^*	74.01	0.82	69.17	0.50	< 0.001
	a^*	0.69	0.30	1.05	0.07	N.S.
	b^*	20.15	1.04	21.64	0.30	N.S.

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REPORTS FROM WORKSHOPS ON -

GRAIN LEGUMES FOR FOOD AND TRADE

1. ADDED VALUE TO LEGUME PRODUCTS

Convenor - **G.D. Hill**

Our group began by considering the question of processed soya bean imports. A processor suggested he would be happy to buy 50,000 t of whole soya beans, let alone any soya bean meal. We decided, after discussion, that it would be best to have a solvent extraction plant, which is unfortunately the most expensive sort of soya bean processing plant.

There was someone in our group from Mexico who has had experience growing the crop, who indicated that by crushing alone you produce a high oil content meal which unfortunately has a short shelf life.

Another area of discussion was the substantial increase in the consumption of vegetable oils in New Zealand in recent times. These vegetable oils, besides being used for such things as cooking and baking, are also used in other products like margarine, salad dressings and mayonnaise. Workshop members from industry seemed to think that there would be no real problem with the disposal of the meal created from crushing, to the pig and poultry industry.

One suggestion made was the production of a fresh green product and this ties in with the suggestion for green chick peas and green soya beans.

We discussed in detail the most suitable area for soya bean growing. We concluded that the North Island was probably going to be the most suitable because of the high shipping costs in the South Island and also because that would be where the main market would be for oil and for the pigs and poultry which could be produced from the meal. It would increase the cost of the product to grow it in one part of New Zealand and process it in another part.

The alternative scenario if competing land use options were to preclude this, would be for crop production and animal production to take place in the one area.

We then considered ways of increasing the value of other products and we decided the one thing we needed to exploit in more depth was the snack food market. A few years ago the value of consumption of potato crisps in the United Kingdom was on an exponential growth phase. (Dietitians are probably horrified at the thought that we increase snack food products!) However, there are a variety of ways in which legumes can be prepared which don't necessarily have to be bad for you. Particularly legumes like chick peas - they can be soaked in water and then roasted. In Mexico they also soak and roast faba beans. They are eaten with or without chilli, depending on your taste.

There was also a suggestion that we ought to improve the convenience of legumes with the production of canned or dehydrated refried beans which are also available in Mexico.

The other thing discussed was the possible use of extrusion processes for snack foods, and also popping. I had seen some work done on the extrusion of beans in Nante in France and in the United States. People are also looking at popping various types of beans.

We returned to the discussion of the possibilities of prepackaging legume foods to make them more convenient. We decided the place to do research on this would be the Food Science School of the University of Otago. Firstly, to see how legumes reconstitute after they are frozen because some things don't reconstitute very well. Secondly, the possibility of freeze dried products to which water is added to make them suitable for use.

There was brief discussion on the production of specialised foods from legume products specifically for diabetics, as they comprise 5 % of the population. It was stressed that if such foods were prepared, no sugar and very little salt should be added.

Finally, the group discussed, very briefly, the textured vegetable protein market, and we decided that it was an idea that has had its day.

There were no questions, but Mr. Rees commented that another idea was the use of cooked chick peas in salads. They are considered to be very tasty.

2. QUALITY CONTROL AND REQUIREMENTS

Convenor - **R. Rees**

Lentils - New Zealand is a few years ahead of Australia in the commercial development of lentils. However, we should be changing the target market away from the third world to the developed world, we should be aiming for a machine dressed product for Europe and the United States.

Lentil colour is an issue at the moment, particularly for the traditional markets that already know lentils. They recognise a red colour, they want that red colour, they don't like other variables. There is great variation in lentil colour and there are opportunities to introduce new lentil colours to a broader market, the less traditional markets.

The size of lentils is important in cooking. Shorter cooking times are an advantage: small lentils and split lentils lend themselves to more efficient cooking. They compare well with chickpeas which have to be soaked overnight or they take a lot longer to cook.

Chickpeas Desi chickpeas are a bulk market for third world markets so I prefer a graded Kabuli product which may go to Europe. Farmers have less control over quality than processors. Lentils and chickpeas can be considerably improved by processors who have an opportunity for adding value for the European and United States markets by dressing and grading.

There is a grading system in place for field peas but the volume New Zealand is exporting is very low. Why aren't you producing more volume? The markets are there. Is the grading system a deterrent to the development of the stock food market? If it is, then what is needed is a concentration on the benefits of developing our stock feed industry and to then to look at yields and competitive prices. The whole question of the place of feed grains on the farm, needs consideration.

Another question which arose was is the grading system relevant to the export system? Has it cut you out of the stock feed export market, has it stopped you looking at other options like chickpeas and lentils for the export market?

The group felt that we need to work much more closely at the retail level. What is happening with green peas at the moment is good in that you are working to the consumers specification for size etc.. There are a range of countries, particularly the newly industrialized countries who are looking for more and more retail products as their income rises quickly. The New Zealand Dairy Board perhaps, is an ideal role model for you to not only use, but to work with - to look at the way they have expanded their distribution systems. Perhaps as an industry you should work with a company like Watties, that has access to retail distribution systems. What you then have to do is expand your range of products to meet the needs of the consumers who use that system.

The obvious need we identified was for something like the establishment of a New Zealand Grain Legume Commission or Association, where there is a lot more direct marketing input by all members of the trade. There is an information problem, not only a marketing information problem but a technological information problem. I realise that it is difficult to get together as a group but the group believe that it would be profitable to look at the establishment of something like what the United States has.

Marketing information is lacking. You need to look at the channels of communication so that you know at all times what the top five grain legume opportunities are. Because the industry is changing at such a rapid rate the whole industry needs to be on top of the volatility, understand what is causing it, what's happening with Indian policy for example, what's happening with European policy - are the markets still open, are the market rumours fact or fiction? You must aim some of your resources right through the production and marketing chain.

Lastly, what needs to be encouraged is the market niches. You have an opportunity, viable quality standards in place, you must work to explore some of those. Work towards the retail market, work towards the fresh vegetable market. These products are available. It requires R & D and someone must picks up the tab for that or lobby government to help with the cost. A New Zealand Grain Legume Association may be a start, a levy on producers may be another way. But certainly if Coca Cola were in this industry, they would be taking 10 % off the top for R & D.

Question: In terms of quality of product, what advantages would there be to the New Zealand industry, in farmers changing from the current blue pea type to the Australian dun type?
Answer: I would not recommend it because you would be reducing your value. I would prefer to look at possibilities of expanding your production of the blue peas and sending them out in bulk particularly to the Indian sub-continent. I think that the United States will recognise, in the not too distant future, that the old advantage of containerised shipping of blue peas may be in its last days.
Question: There's a tail end of the blue pea market that currently goes to stock feed but we can produce a quality product. The blue pea has less value than the dun pea in animal food because of high levels of trypsin inhibitors.
Answer: I am not a nutritional specialist but I am surprised to hear that. However, you are only looking at a small percentage of peas in the feed mix any way. We can introduce up to 30%.
Question: You can use the white Australian dun pea like that but in New Zealand we would run into strife if we did it with the blue peas.
Answer: I would prefer a nutritionist to comment but perhaps the answer is to grow a white pea where you have got both a food market and a feed market. I think you would be a lot better off that way we are trying to move towards a white pea in Australia, we have too many green ones our current varieties.
Question: Do you know what the trypsin inhibitor levels are on local peas?
Answer: Medium-high. You get the whole range in tests from very low trypsin levels to very high. There was some work reported on this in a paper by D.C. Johns in the *Journal of Agricultural Science*.
Comment: Other grain legumes, lentils and chick peas, often ferment and that's very good stock food. Blue offal are not a good stock food but it's a very good adjunct to the stock food industry. The New Zealand maple has a 30 % stock feed market niche and there are advantages of moving into greater production of maples. Yellow peas, have a substantial market for stock food, but you must get high yield rather than quality.

3. UTILIZATION OF LEGUMES: THE PRESENT AND FUTURE

Convenor - **G.P. Savage**

Promotion: Legumes suffer from an image problem, they are not highly valued foods in western diets. The main problem appears to be a general lack of knowledge of how to cook and process them. People who do not attempt to use them often make the comment that it takes a great deal of time to cook them properly.

The presentation of baked beans ready to eat in tin cans is perhaps the most well known legume product on the market. The important feature is that they are presented ready cooked in a tasty sauce. All they need is to be warmed up and they are ready to consume. Variations on baked beans in tomato sauce, such as curried beans and Mexican beans, are beginning to be introduced but they are not regarded by the public as high value foods.

Lentils and beans are widely used commercially to thicken soups and sauces, but this does not use a large quantity of legumes. Growers and producers would like more to be consumed.

As far as western diets are concerned there appear to be a number of good reasons why more legumes should be introduced into the diet. The main reason for their inclusion is to reduce the amount of meat eaten. This would reduce the amount of saturated fat in our diets which is a goal for improving our diet. Legumes also contain useful amounts of dietary fibre which again should be increased in our diet. It is unfortunate that the processing of some legumes, e.g., legumes for human use, involves the removal of the testa which reduces the amount of dietary fibre in, for instance, split lentils. There is evidence emerging that some legumes contain good levels of saponins which tend to reduce blood cholesterol if eaten in sufficient amounts.

A considerable amount of work needs to be done to turn legumes into convenience foods. They need to be presented cooked and processed ready to eat. Their presentation in plastic pouches like the "boil in a bag" foods would greatly enhance their profile. They should be presented with different and exciting sauces.

Another possibility is vacuum packed cooked beans with a range of sauces sold separately - like spaghetti sauces. There appears to be some mechanical processing problems that need to be overcome in developing ready-to-use foods.

It was also suggested that education was needed to promote the use of legumes. The Heart Foundation is a good forum for this type of health education work. The workshop members tasted a number of products containing added ground lentils and chick peas such as bread, cakes and biscuits prepared from household recipes. Although these products were prepared by a dietitian it was clear that they could have been prepared in most homes. All that is needed is to encourage homemakers that legume products are nutritious foods. The development of a coherent education programme would be an important step.

It was also recommended that the development of snack foods using legumes should be encouraged. The development of the existing range of peanut products should be a guide to what may be possible. There are a number of snack foods that are commonly eaten in Indian and Arab speaking lands that use legumes, particularly chick peas and white peas. It is hoped that snack foods based on beans and lentils could be developed which would include extruded lentil flour products.

The recent increase in the use of sprouted legume seeds in our diets should be continued. This is a very good example of adding value to a very basic product. For the producer there is considerable increase in volume and consequently profits. It was thought that if more data was available it might be possible to promote legume sprouts as a nutritious food.

It was noted that New Zealand has developed a useful export market for lentils in a very few years and could produce more for the home market if demand increased. It is technically possible to select more nutritious varieties of various legumes, including lentils. At present this would be a major addition to the current selection criteria for varieties and cultivars based only on suitability to our climate and soils.

Overall, legumes need a new nutritious image before they will be more widely accepted in human diets. It was felt that manufacturers need to develop a vision to promote new legume based products. The sprouted legume market should be encouraged and should be backed up with good reliable nutritional data.

***The feed industry*:** The stock food industry is happy to take up second grade legume seed for use in food compounding but is not prepared to offer high prices for legume protein. The main problem appears to be one of variable supply. The compounding industry would prefer to have reliable supplies of legume products and would prefer to have supplies of products it understands well. The stock food industry would prefer a steady and reliable supply of soya bean meal. This meal has been processed to remove the oil, a valuable commodity in itself, but in the process the many heat labile anti-nutritive factors have been degraded making soya bean meal an easy product to include in many formulations.

Generally speaking, nutritional improvement does not seem to be a high priority although breeding out trypsin inhibitors would seem to be a major task. Though perhaps identifying the trypsin levels in the different cultivars of peas and beans is something that needs to be considered.

***Question*:** There appears to be an enormous potential for an easily cooked legume product. There could also be enormous savings on energy not only for New Zealand but perhaps more importantly in developing countries, if some way we could cut down the amount of energy needed to process the product.

***Answer*:** Yes, there is an energy problem in developing countries. They are also the countries that are least able to invest in R & D to resolve the problem. In environmental terms, there is an enormous amount of firewood that's cut annually for cooking and obviously technology for easily-prepared legumes, would have pay-offs in this area.

***Comment*:** I think 'this problem' is also the thing that makes legumes so attractive as a foodstuff in developing countries. The fact that they are reasonably hard makes them resistant to attack by insects and reduces storage losses. So maybe if you produce one that is very easy to cook, it might then become very easy to be eaten by weevils and other bugs. Although trypsin inhibitors give a certain amount of protection against attack by insects.

GENETIC ENGINEERING FOR GRAIN LEGUME IMPROVEMENT

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ABSTRACT

Progress toward the genetic engineering of grain legumes such as peas is well advanced. Using tissue culture technology, whole plants can be efficiently regenerated from individual cells of immature cotyledons from pea cultivars important in New Zealand. These cultivars are also excellent hosts for Agrobacterium-mediated transformation. Using this approach we have selected transformed hairy root cultures of pea that express two foreign genes: kanamycin resistance and - glucuronidase. We are currently attempting to combine our regeneration system with the selection of transformed cells to produce transgenic plants. Once developed, we intend to exploit this technology for the development of pest and disease resistance in peas. Our immediate target is pea seed-borne moasic virus using the now well established approach of "coat protein mediated virus resistance". To date we have cloned, sequenced and manipulated the coat protein gene of this virus to permit expression upon transformation into plants, and are currently attempting gene transfer to peas.

Additional key words: tissue culture, regeneration, transformation, **Agrobacterium tumefaciens, Agrobacterium rhizogenes,** ***tumours, hairy roots, insect resistance, virus resistance, pea seed-borne mosaic virus.***

INTRODUCTION

Plant genetic engineering is a multidisciplinary area of scientific research. It requires co-operation and involvement of scientists with a wide range of skills, including molecular biology, biochemistry, microbiology, tissue culture and genetics. Once genetically modified plants are obtained there is a great deal of testing required not only to determine if the plants are only altered in the particular desired trait, but also what effects may possibly occur when the plant is released into the environment. In this phase of research the skills of plant breeding, agronomy, food technology and ecology all become important.

In this paper we present an overview of genetic engineering technology as it applies to grain legume improvement, with the main emphasis on peas (*Pisum sativum*). We focus on the current status and direction of research, rather than discuss the various technologies available. (For reviews see Conner *et al.*, 1990; Gasser & Fraley, 1989). To achieve successful genetic engineering of plants several lines of research must intersect. These include the ability to regenerate plants from individual cells, the ability to transform genes into plant cells, the cloning of target genes to be transferred and the linking of their coding regions to appropriate regulatory elements.

REGENERATION OF PEAS IN TISSUE CULTURE

Organogenesis: **There are a number of reports of successful regeneration via organogenesis in peas (Mroginski & Kartha, 1981; Rubluo *et al.*, 1984; Hussey & Gunn, 1984; Natali & Cavallini, 1987). All these reports used immature tissue as explant material. This included embryos, leaflets, plumules and shoot apices. In general the reports indicate a low efficiency of regeneration with up to 37 % of explants responding, but generally the response reported was significantly lower. The appearance of adventitious buds or shoots occurred after a relatively long period in culture (from six weeks onwards; Natali & Cavallini, 1987; Mroginski & Kartha, 1987). Of the plants produced**

from tissue culture and examined cytologically, there was a high frequency of tetraploidy and aneuploidy among the expected diploids.

At Crop Research Division we have developed a medium (modified from Hinchee *et al.*, 1988) that successfully allows regeneration for New Zealand conditions and cultivars. Shoot regeneration is rapid and although there are marked genotype differences, all cultivars tested have regenerated plants. For cultivars 'Bohatyr' and 'Pania' grown under greenhouse conditions, 70 % of explants produced shoots (Table 1). Our method uses the distal two-thirds of immature cotyledons with embryos (including the cotyledonary nodes) removed. The most responsive stage of development of the seed is at the "green pea" stage, i.e. when the cotyledons fill the seed and at the optimal time for picking fresh eating peas. The cotyledons are placed with their flat surface in contact with the culture medium. After 10-14 days some callus develops and shoot primordia are clearly visible. Cotyledons continue to respond for up to two months. Shoots can be excised, rooted and successfully transferred to soil. Upon subsequent subculture of remaining cotyledonary material further shoots develop.

Somatic embryogenesis: Kysely *et al.* (1987) reported whole plant regeneration via somatic embryogenesis in peas using immature embryos or shoot apex segments as explants. Induction of the somatic embryos required 2,4-D or picloram, and genotypic differences were evident. The frequency of embryo production was low with only an average of two somatic embryos for every zygotic embryo cultured. Of the nine plants recovered, six were diploid and three were tetraploid.

Protoplast isolation and regeneration: Recent work on protoplast isolation and regeneration to shoots and plants has been successful. Puonti-Kaerlas & Eriksson (1988) used a bead culture system and found the cultivar 'Filby' gave an 80 % response (i.e. development of mini-cell colonies). Shoot regeneration was obtained in cultivars 'Petra' and 'Stivo', but these shoots were not able to be rooted.

Lehminger-Mertens & Jacobsen (1989) produced protoplasts from embryo axes of mature seeds. Somatic embryos were produced on the protoplast derived calli by using strong auxins (2,4-D and picloram) in association with increased osmolarity in the medium. Cultivars 'Belmen' and 'Brite' gave relatively high rates of embryo induction (20 - 30 %). The authors were able to induce the somatic embryos to mature and germinate. The plants so far produced have a normal phenotypic appearance.

AGROBACTERIUM-MEDIATED TRANSFORMATION

Agrobacterium-mediated transformation has been the most successful method of gene transfer into plant cells. This system takes advantage of the natural genetic engineering ability of the bacterium. Two main species of *Agrobacterium* are used for gene transfer: *A. tumefaciens* and *A. rhizogenes*. Each work on similar principles, but the outcomes vary.

Agrobacterium tumefaciens: In its natural state this bacterium infects wound sites and causes the formation of crown gall tumours on many dicotyledonous plant species. During tumourigenesis a specific segment of bacterial tumour-inducing (Ti) plasmid, the T-DNA, integrates into the nuclear DNA of the plant cells. These plant cells express the T-DNA genes which encode enzymes responsible for phytohormone biosynthesis (causing the tumorous growth) and for opine production. The phytohormone biosynthesis genes on the T- DNA can be deleted to produce "disarmed' strains. In their place coding regions of other genes under the control of appropriate plant regulatory sequences can be inserted. Such "disarmed" strains of bacteria are still capable of gene transfer, and since they do not induce tumours, complete plants can be regenerated from the transformed cells using tissue culture technology.

In the disarmed strains the genes inserted usually include a gene for antibiotic or herbicide resistance, which allows transformed cells to be conveniently selected by growing the plant material on an antibiotic or herbicide supplemented medium. For peas we have established that 100 mg/l of kanamycin is an appropriate concentration for selecting transformed cells. This level inhibits the growth in culture of wild-type cells and causes existing shoot material to become chlorotic.

We have also established that peas (and other legumes) are a good host for *Agrobacterium* (Table 2). We have not yet selected kanamycin-resistant cell cultures of pea using disarmed strains of *Agrobacterium*. Puonti-Kaerlas *et al.* (1989) reported the selection of kanamycin-resistant cells following cocultivation of pea shoot cultures with a modified Agrobacterium tumefaciens strain, but they were unable to regenerate shoots. Recently the regeneration of transgenic pea plants with kanamycin resistance and -

Table 1: **Analysis of pea regeneration from immature cotyledons after three weeks in tissue culture (Grant & Frew, unpublished results).**

	Pea genotype	A Standard*	B +3 mmol glutamine	C B + 56.8 umol asparagine	D A + 100 mgl^{-1} inositol
1	Bohatyr	31 %	70 %	42 %	33 %
2	Almota	15 %	-	-	-
3	OSU 442-15	40 %	10 %	33 %	19 %
4	017	32 %	0 %	-	20 %
5	985-990	38 %	52 %	-	-
6	Pania	44 %	47 %	41 %	70 %
7	FR80-1724	9 %	3 %	4 %	4 %
8	Whero	25 %	-	-	-

* Standard medium: B5 macro and micro salts, vitamins; MS iron; 1.15 mgl^{-1} BAP; 2.0 % sucrose; 0.8 % Difco agar; pH 5.8.

Table 2: **Host range of *Agrobacterium tumefaciens* strains on pea genotypes grown in the glasshouse: - no response; + tumours formed (Grant & Frew, unpublished results).**

Pea genotype	*Agrobacterium tumefaciens* strain				
	Nt*	Ach5	A281	C58	LBA4404**
Rover	-	+	+	+	-
Pania	-	+	+	+	-
Whero	-	+	+	+	-
985-990	-	+	+	+	-
599-600	-	+	+	+	-

* Control inoculations without *A. tumefaciens*. ** A disarmed strain of *A. tumefaciens* ACH5

glucuronidase activity has been claimed following cocultivation of epicotyl and nodal explants from etiolated pea seedlings with modified *A. tumefaciens* (de Kathen & Jacobsen, 1990). Another grain legume, *Glycine max* (soya bean) has also been successfully transformed by co-cultivation of *A. tumefaciens* with cotyledon explants (Hinchee *et al.*, 1988).

Agrobacterium rhizogenes: *Agrobacterium rhizogenes* is a promising alternative to *A. tumefaciens* for obtaining transformed plants. Essentially this bacterium acts in the similar manner to *A. tumefaciens*, but instead of tumour induction via the Ti plasmid, *A. rhizogenes* generally produces roots via the Ri (root-inducing) plasmid. The roots produced are known as "hairy roots" because phenotypically the roots have a fine, highly branched appearance.

We have examined the host range of several *A. rhizogenes* strains on a range of pea genotypes (Table 3). Only one strain of *A. rhizogenes*, A4T, gave the typical hairy root response. The other six strains gave tumours or no response.

Table 3: Host range of *Agrobacterium rhizogenes* strains on pea genotypes: - no response; t tumours; hr hairy roots (Conner & Williams, unpublished results).

Pea genotype	*Agrobacterium rhizogenes* strains						
	TR7	TR101	TR107	8196	15834	A4	A4T
Proton	t	t	-	-	t	-	hr
11/2	t	t	-	-	t	-	hr
Summit	t	t	-	-	t	-	hr
Canterbury 39	t	t	-	-	t	-	hr
Whero	t	t	-	-	t	-	hr
Puke x Whero	t	t	-	t	t	-	hr
Maro	t	t	-	-	t	-	hr
142a	t	t	-	-	t	-	hr
Bohatyr	t	t	-	-	t	-	hr
Birte	t	t	-	-	t	-	hr

We have used the A4T strain of *A. rhizogenes* containing the binary vector pKIWI 110 (Janssen & Gardner, 1990) to produce transformed hairy root cultures of the cultivar Pania. The modified T-DNA of pKIWI 110 contains genes for kanamycin resistance and -glucuronidase. We therefore selected the transformed hairy roots on medium with kanamycin and further confirmed their transformed nature by detecting expression of - glucuronidase using a simple histochemical test.

An advantage of using *A. rhizogenes* transformation is that hairy roots from many species can be readily regenerated into plants without having to create disarmed strains. *Glycine canescens*, a wild relative of soybean, has been regenerated from hairy roots (Rech *et al.*, 1989). Other legumes in which this is possible include Lotus (Jensen *et al.*, 1986), Medicago (Sukhapinda *et al.*, 1987) and Stylosanthes (Manners & Way, 1989). We are currently attempting to regenerate pea plants from our transformed hairy roots.

Even if we are unable to regenerate plants from these hairy roots, transformation of pea with *A. rhizogenes* offers a very easy and convenient system in which we can study the expression of foreign genes in the grain legumes. As molecular biologists construct gene vectors for grain legume transformation, we will be able to assess rapidly which of the various versions constructed show the highest expression in peas.

OTHER APPROACHES TO TRANSFORMATION

While our efforts to genetically engineer peas have so far concentrated on using Agrobacterium to transfer the genes, we will in the near future be looking at two further options for transformation. One approach involves direct DNA uptake into protoplasts as there are now reports of regeneration of whole plants from pea protoplasts (Lehminger-Mertens & Jacobsen, 1989). A second approach involves the gene gun, where DNA coated particles (tungsten or gold) are accelerated into plant tissue. Both of these approaches have been successfully used to transform other grain legumes (Kohler *et al.*, 1987; McCabe *et al.*, 1988).

GENES TARGETED FOR TRANSFER TO PEAS

Once a transformation system is established for peas, the transfer of agriculturally useful genes can be achieved by constructing vectors with the appropriate gene adjacent to a kanamycin-resistant selectable marker gene. The primary focus of our genetic engineering programme is the transfer of genes for pest and disease resistance into arable and vegetable crop plants, including peas (Conner *et al.* 1990). In the longer term we anticipate applications for improvements in grain quality, especially nutritional composition.

Insect resistance: The major insect pests of pea for which we are targeting resistance are Heliothis, Bruchus and Etiella. Two approaches which have been successful against similar pests in other crops offer considerable potential. These include the use of genes encoding insecticidal BT proteins from the bacterium *Bacillus thuringiensis* and proteinase inhibitor genes from other plants. The activities of specific proteins are currently being screened against the targeted pests by other DSIR divisions, after which the appropriate genes will be cloned for subsequent transfer to peas.

Virus resistance: It is now well established that genetic engineering technology can be used to genetically manipulate plants for resistance to viral diseases. This involves the integration and expression in plant genomes of DNA sequences corresponding to specific genetic components from plant viruses, particularly the viral coat protein gene(s). Although the mechanisms of this viral protection are not completely understood, a number of crops have been protected against infection by tobacco mosaic virus, alfalfa mosaic virus, cucumber mosaic virus, soybean mosaic virus and potato virus Y. For grain legumes our initial interest is in developing resistance to pea seed-borne mosaic virus. This virus causes important disease in the world trade of pea and lentil seed, affecting yield, quality, and appearance. Because of its seed-borne nature, it has been transmitted internationally.

To produce virus-resistant peas, we are making use of the "coat protein mediated virus resistance" phenomenon first reported by Powell-Abel *et al.* (1986) for tobacco mosaic virus. We have cloned a portion of the viral genome containing the pea seed- borne mosaic virus coat protein gene and determined its nucleotide sequence (Timmerman *et al.*, 1990). The pea seed-borne mosaic virus coat protein is encoded at the carboxy-terminal end of a long polypeptide, as is the case with other potyviruses. So that this gene can be expressed in pea plants without other viral gene products, it was necessary to modify the gene extensively. An ATG codon in an optimal translation initiation context was added to the start of the coat protein gene. This was done using the polymerase chain reaction (Saiki *et al.*, 1988) and specially designed oligonucleotide primers. The modified coding region was then inserted between a cauliflower mosaic virus 35S promoter sequence and a 3' poly (A) addition sequence in a plasmid expression vector which also carried a gene for expression of kanamycin resistance in plant tissues. These two linked genes have been inserted into disarmed T-DNA, and mated into the two species of Agrobacterium discussed above. Experiments are currently underway to transform two crops, peas and potatoes, with this coat protein gene. Expression of the modified coat protein gene will first be characterised in transgenic potato plants using immunodot or Western blotting techniques (Towbin *et al.*, 1979).

Transgenic pea plants expressing the gene will be tested for their susceptibility to infection by this virus and other related viruses under controlled glasshouse and field trial conditions. The development of virus-resistant germplasm using this technology will result in the production of clean pea seed for international trade.

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MODELS FOR ANALYSING THE GROWTH AND YIELD OF PEA CROPS

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ABSTRACT

The use of a modelling approach to analyse the growth and yield of pea crops, and thus identify the causes of yield variations, is described. The value of the approach for establishing research priorities is highlighted and progress in two current research projects which are focussing on specific aspects of pea yield variability is outlined. One project aims to define the effects of timing and severity of water deficit on pea crops in terms of the responses of the main determinants of yield. In the second project harvest index stability, which is an important contributor to yield variability, is being studied. The aim is to identify environmental conditions and genotypes associated with stable, high harvest index.

Additional key words: ***yield variability, water deficit, harvest index, yield determinants, environment, genotypes.***

INTRODUCTION

Yields of pea crops are more variable than most other arable crops. Identification of the management, cultivar and environmental factors which cause the variations is an important research objective. The aim is to find ways to reduce the variations and thus improve average yield.

Good crop management advice is already available (Jermyn, 1984). In contrast, much less is known about environmental influences on the growth and yield of pea crops, or cultivar characteristics associated with stable, high yield potential. Gallagher *et al.* (1983) pointed out that environmental influences on crops are usually much greater than the effects of crop management. This is especially true for peas. Thus it is important to understand the processes which contribute to the growth and yield of pea crops, how these processes vary among genotypes, and the effects on them of environmental factors which cause the most yield variability.

One way to achieve this is to use a modelling approach to analyse the growth and yield of pea crops. This approach was discussed by Wilson (1987) who advocated it as a way to identify causes of yield variation. In this paper we review the approach briefly, describe how it can be used to identify research priorities for reducing pea yield variability, and then discuss progress in two current research projects.

CROP MODELS

The development and use of models which simulate crop growth and development has become popular over the last 20 years as advances in computer technology have made it possible to handle the complex calculations required.

A model is a simplified, quantitative description of a crop expressed as a series of equations. It consists of relationships representing the main physiological processes which contribute to growth and yield. These include genotype-specific parameters, and the effect of environmental factors on them. Plant processes previously studied separately are thus organized in a logical manner. Therefore, a model allows improved understanding of a complex system such as a crop and its environment by combining fragmented knowledge about it into a unified whole.

Once developed, models can be used to analyse and predict the behaviour of the systems they represent. Crop models have varied uses:

* Setting research priorities by identifying those environmental and plant factors which most influence crop performance.
* Helping identify gaps in knowledge of plant processes and crop-environment relationships.
* As frameworks for logical analysis of experimental results.
* Defining crop responses to the environment.
* Predicting likely effects of management decisions on crop performance.
* Identifying crop and cultivar characteristics associated with high yield potential.

Many models of varying complexity have been developed for a range of crops, particularly wheat, maize, soybeans and cotton. Most use a reductionist approach which synthesises understanding of a crop system from knowledge of its constituent parts. However, in our research on peas and other crops we follow the holistic approach of Charles-Edwards (1982) and Charles-Edwards *et al.* (1986). This approach aims to understand crop performance by deduction or inference, using models to analyse observations of the behaviour of whole, intact crops. It has the advantage that the models are relatively simple, and contain only a few parameters which can all be estimated directly from field measurements. They are defined at the crop level of biological organisation, rather than in terms of processes occurring at some lower level of organisation as in reductionist models. Nevertheless, the parameters can be further analysed in terms of more basic physiological and physical processes of plant growth (Charles-Edwards & Vanderlip, 1985).

APPLICATION OF MODELLING TO PEA CROPS

Our main reason for using a modelling approach to analyse the growth and yield of pea crops is to establish research priorities by identifying the main crop and environmental factors which cause yield variation. The analyses are based on the approach proposed by Charles-Edwards (1982) which identified five major determinants of yield:

1 The amount of solar radiation intercepted by a crop canopy (Q).
2 The efficiency with which intercepted radiation is used in growth (e).
3 The duration of growth (t).
4 The partitioning of total dry matter between different crop parts, especially into those of economic interest (n).
5 The amount of dry matter lost during growth (V).

The growth of crop portion h (e.g. seeds, stems, leaves, roots, etc.) over a duration of t days (Wh) can be written in terms of the five determinants to form a simple model:

$$W_n = \int_o^t (n_n.e.Q - Vn)dt$$

Wilson (1987) discussed how this model has been used successfully to describe the growth of pea crops in a range of conditions, and how it was used to help identify why yield varied considerably among seasons, cultivars, sowing times and irrigation treatments (Jamieson *et al.*, 1984; Wilson *et al.*, 1985). In this paper we describe two current research projects which focus on particular aspects of pea yield variability.

One project aims to define the effects of water deficit on pea crops. Water availability is usually the main environmental factor responsible for yield variability.

The next section describes a current experiment which has the main objective of defining how water deficits of different severities and at different times during crop growth affect the determinants of the model and, ultimately, seed yield.

In the second project, harvest index (HI) stability in peas is being studied. Partitioning of dry matter to the seed is not only sensitive to management and environmental factors, but also differs substantially among genotypes. It is therefore an important contributor to yield variability. The challenge to pea breeders is to identify genotypes with stable, high HI, and the final section describes another current experiment in which individual plant HIs within crops of contrasting genotypes are being examined.

EFFECTS OF TIMING AND SEVERITY OF WATER DEFICIT ON FIELD PEAS

Traditional irrigation management practice is to water pea crops twice, at flowering and again at pod fill, unless rainfall is significantly above or below average. The disadvantage of this rule-of-thumb approach is that it takes little account of water availability to the crop during growth. More recently, irrigation scheduling has been related better to crop water need, with water budgeting and/or soil moisture monitoring being used to account for crop water use, rainfall and irrigation.

Despite this progress important questions remain unanswered, especially about the timing of irrigation in relation to crop development. There are conflicting views about the effect on the growth and yield of pea crops of irrigation close to flowering and during vegetative growth, well before flowering. In previous experiments (Jamieson *et al.*, 1984), we found that yields were reduced by 0.2% for every mm that the maximum potential soil moisture deficit exceeded a critical deficit of 88 mm in a deep silt loam, regardless of when the drought occurred. However, the results were incomplete because we were unable to subject crops to severe water deficits early in the season.

In the 1989-90 season, an experiment with field peas is being conducted in the DSIR/MAF rainout shelter at Lincoln which should answer these questions conclusively, and therefore lead to optimum irrigation management guidelines.

The rainout shelter has the advantage that it allows a crop to be grown under natural field conditions except that it is covered automatically whenever rainfall occurs. Timing and severity of water deficits can therefore be controlled precisely.Twelve irrigation treatments will be applied to the experimental crop using a trickle system which allows measured quantities of water to be applied to individual plots.

The treatments have been designed to expose the crop to a range of timings, severities and durations of water deficit. Except during deficit treatment periods, plots will be irrigated each week with enough water to replace the water used in evapotranspiration during the previous week, as determined by a water budget based on neutron probe measurements of soil moisture. Thus each deficit treatment will start one week after the last irrigation. Plots will be subjected to deficits of several severities either early in growth, during mid-season, or late in crop development. Also, two treatments will be irrigated fully, one to field capacity and the other to replace weekly evapotranspiration. Details of the twelve treatments are given in Table 1.

Crop growth and water use in all plots will be monitored throughout the season to define deficit severities and identify the model determinants associated with yield responses. Radiation interception by the crops and dry matter distribution to seeds, stems and leaves will also be measured because they are likely to be associated prominently with yield differences. Seed yield and yield components will be measured at maturity.

HARVEST INDEX STABILITY

Variable partitioning of dry matter to seed, quantified by HI, has been identified as an important contributor to yield instability in pea crops (Ambrose & Hedley, 1984). Harvest Index is sensitive to management and environmental factors, and also differs substantially among genotypes. The challenge is to identify conditions and genotypes associated with a stable, high HI.

Traditionally, HI is defined on a whole-crop basis, with little regard to the performance of individual plants within crops. However, in pea crops it has been shown that the plant harvest index (PHI) of individual plants can vary from 0 to 70% (Ambrose & Hedley, 1984; Hedley & Ambrose, 1981). Therefore, to improve seed yields the aim should be to have more individual plants with high HIs. As HI is amenable to genetic improvement (Passioura, 1981), it is important to identify the degree to which HI stability varies among pea genotypes. Such an approach should lead to a clearer definition of breeding and selection objectives.

Pea plants are not naturally adapted to growing in crop communities. Hedley and Ambrose (1985) suggested that because of their ancestry as wild, solitary plants not growing in monocultures, it is difficult to define their most efficient form for growing them at the community level. In spite of these uncertainties, individual pea plants are traditionally selected in early generations of breeding programmes because of their superior performance as single, spaced plants.

The plants chosen are usually dominant competitive types, and may have the greatest PHI variability when grown in crop communities (Ambrose & Hedley, 1984). Donald (1968) and Evans (1981) proposed the idea that to achieve the highest efficiency at the community level each plant has to suffer minimum interference from its neighbours, and therefore should be a weak competitor. The success of a pea crop at producing a high yield would thus depend on the ability of individual plants to adapt to a community level.

A project is in progress at Lincoln to test these ideas by aiming to identify pea plant phenotypes which are most suited to growing in communities and therefore have stable, high PHIs and superior yield potential.

As a first step, it was necessary to determine the degree of variation of stability of PHI among different genotypes. Hence, in 1988-89 four lines with contrasting morphological characteristics were selected

Table 1. **Irrigation treatments in the rainout shelter experiment. A dash indicates no irrigation for the week and an 'i' indicates an irrigation.**

Week		Full Irrigation		Early Deficit			Middle Deficit			Late Deficit			
		1*	2*	3	4	5	6	7	8	9	10	11	12
Nov	9	i	i	-	-	-	i	i	i	i	i	i	i
	16	i	i	i	-	-	i	i	i	i	i	i	i
	23	i	i	i	i	-	i	i	i	i	i	i	i
	30	i	i	i	i	-	-	-	-	i	i	i	i
Dec	7	i	i	i	i	i	-	-	-	i	i	i	i
	14	i	i	i	i	i	i	-	-	-	i	i	i
	21	i	i	i	i	i	i	i	-	-	-	i	i
	28	i	i	i	i	i	i	i	i	-	-	-	i
Jan	4	i	i	i	i	i	i	i	i	-	-	-	-
	11	i	i	i	i	i	i	i	i	-	-	-	-
	19	i	i	i	i	i	i	i	i	-	-	-	-
Expected deficit severity (maximum potential soil moisture deficit, mm):													
		35	95	50	70	120	55	85	120	175	140	105	70

* Treatment 1 irrigated to replace weekly water use and treatment 2 irrigated to field capacity.

from sixty F_{12} lines in a yield trial in the DSIR Crop Research field pea breeding programme. The lines were classified in three ways: as conventional (C) or semi-leafless (S) foliage type, vigorous (V) or non-vigorous (N) and growth of uniform (U) or non-uniform (N) appearance.

Samples from the trial exhibited variability among the lines in their PHI distribution. For example, the CVN line had a higher proportion of barren (PHI = 0) and poor performing (PHI < 33%) plants than the SVU line (Figure 1).

In the 1989-90 season, a field experiment is being conducted to determine if the differences among the four lines are attributable to agronomic, physiological or genetic influences, and thus to identify if any one of them produces a stable, high PHI.

The lines have been sown at five plant populations: 9, 64, 100, 225 and 400 plants/m^2. The lowest population approximates the spaced planting arrangement used for single plant selection in the early generations of breeding programmes, the 100 plants/m^2 is a commercial plant density, and the two highest populations should force inter-plant competition early in canopy development.

The experiment will be managed to achieve potential yields by keeping all disease, water and nutrient conditions non-limiting. The emergence date and seedling growth of 100 plants per plot will be recorded to examine their influence on final harvest performance. The harvest index and other parameters of the yield of individual plants will be measured at maturity.

CONCLUSIONS

We have aimed to show how modelling can be used to identify how genotypic, management and environmental factors cause yield variations in pea crops, and have used two examples to show how the approach can lead to:

* Better understanding of the mechanisms underlying yield variation.
* Identification of strategies to improve yield stability.
* Development of experimental approaches to investigate the principal factors causing yield variation.

These results are usually not possible using traditional agronomic approaches to yield improvement.

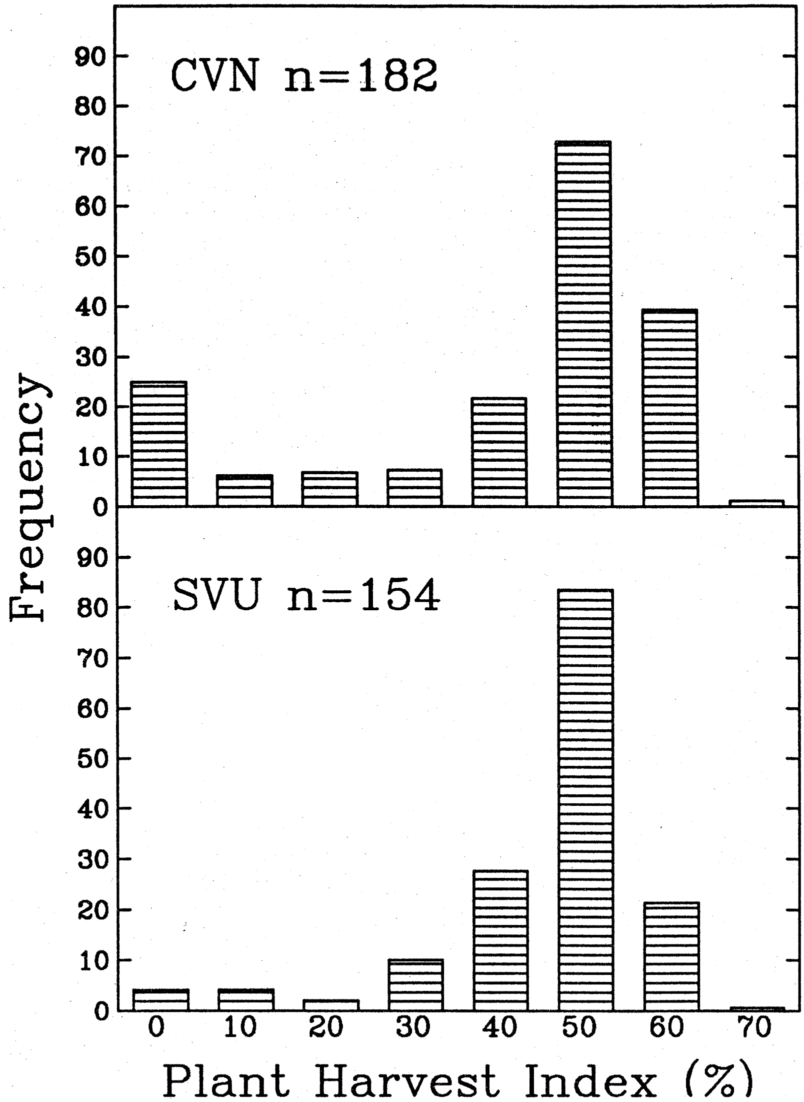

Figure 1: **Plant harvest index frequency distributions for the conventional, vigorous, non-uniform (CVN) and the semi-leafless, vigorous, uniform (SVU) lines from the F_{12} pea yield trial in 1988-89.**

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PEA GROWTH MODELLING: RESPONSE OF N FIXATION TO DROUGHT

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ABSTRACT

A model of pea N fixation and drought interactions is proposed. The design is described for a series of trials being undertaken by the authors to test the model and thereby develop a strategy to alleviate potential N fixation problems in drought stressed peas.

Additional Key Words: Pisum sativum, *water stress, nitrogen fertilization, super nodulation.*

INTRODUCTION

This is a description of work in progress rather than final results and must therefore be regarded as highly speculative. The research is aimed at two ends: (1) To test a theoretical model of the response of nitrogen fixation and dependant growth of a pea crop to a period of water stress; (2) To evaluate two alternative methods for overcoming yield reductions predicted by the model.

The model has been developed from observations on a variety of legume crops but is as yet untested.

THE MODEL

Trials conducted on soybeans (McNeil & La Rue, 1984) have indicated that a stress applied to N fixing nodules could reduce total plant yield. In these trials small doses of applied NO_3^- were sufficient to substantially reduce N fixation and consequently yield (Table 1).

Presumably NO_3^- inhibition of N fixation more than compensated for the additional N available from the nitrate. This produced a 33% reduction in seed N yield compared to unfertilized controls, for a treatment receiving 40 kg N/ha.

Other stresses have been demonstrated to reduce N fixation in legumes. Water stress has substantial effects (Sprent & Bradford, 1977). A single drought stress and stress induced by nwaterlogging have been shown to significantly reduce yields in chickpeas in Northern Australia (McNeil, *et al.*, 1986).

TABLE 1: Effect of applied nitrate on soybean yield and N fixation (after McNeil & La Rue, 1984).

NO_3^- added week 3 kg N/ha	NO_3^-added week 8 kg N/ha	Seed yield g N/Plant	Plant N from fixation %
0	0	0.82	83%
20	0	0.78	67%
20	20	0.55	56%
100	0	0.77	59%
100	100	0.89	54%

The following model (Figure 1) is proposed for the response of peas to water stress.

(1) Plant GR (Growth Rate) = The lower of (a) light limited C fixation rate, (b) N fixation rate.

Under normal circumstances these two are in balance (between t_0 and t_1, Figure 1).

(2) With application of drought both rates (a) and (b) fall substantially in balance (t_1, Figure 1).

(3) With removal of drought the light limited C fixation rate recovers rapidly (t_2, Figure 1) but N fixation may take longer due to a need to re-establish effective nodule mass (t_3, Figure 1).

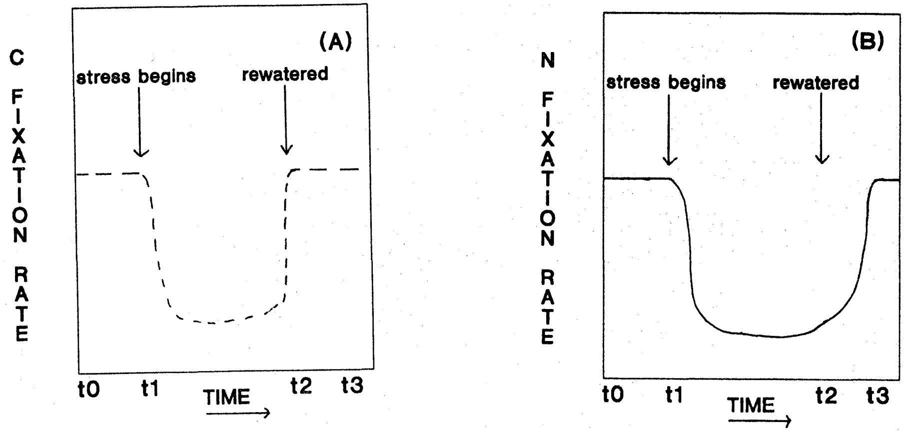

Figure 1. Proposed model of pea growth responses to water stress.

These responses result in a period of growth (between t_2 and t_3, Figure 1) strongly limited by N fixation rate after drought stress.
This response is similar to that postulated after a NO_3^- stress using the data given in Table 1.

Measurements of N fixation and growth rates following a drought stress and comparisons with responses of non-fixing plants should indicate whether the N fixation limited growth period between t_2 and t_3 in Figure 1 actually exists.

OPTIONS FOR OVERCOMING THE PROBLEM

It is of great importance for crop modelling that the understanding gained of crop responses should lead to a method for improving crop performance. Two are suggested by this model.

(a) If N was added at or prior to t_2 then growth could recover based on NO_3^- reduction rather than N fixation. This possibility is suggested by Table 1, where addition of 200 kg N/ha actually increased yields relative to unstressed controls.

(b) If the potential N fixation rate was raised then it would be less limiting. This could occur if supernodulating peas (Postma *et al.*, 1986) were drought stressed.

Both of the above options are being tested.

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PLANT GROWTH REGULATORS AND GRAIN LEGUMES

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ABSTRACT

The feasibility of using synthetic plant growth regulators (PGRs) for manipulating the stature, dry weight partitioning and seed yield of grain legumes is discussed. The triazole PGR's paclobutrazol and triapenthenol have been field tested and have produced positive responses.

Paclobutrazol reduced stem height in field bean (*Vicia faba*) by 13.8 %, eliminating major lodging problems. In addition there was an overall increase in yield of 42.1 % (190 to 270 g m^{-2}). All yield components were enhanced, but particularly the number of pods (+ 37.3 %). The overall increase in harvest index was highly significant (25.3 to 34.4 %). The increase in yield was linked to increases in flowering and pod retention, particularly on branches.

In lentil (*Lens culinaris*) effects were less pronounced but both paclobutrazol and triapenthenol apparently increased seed yield although not all effects were significant.

The advantages of PGR use in enhancing seed yield and improving aspects of grain legume crop management are discussed. The complex interactions between PGR treatment, soil and climate factors and the potential for improved crop production are considered.

Additional key words: *Plant growth regulator, PGR, paclobutrazol triapenthenol, grain legume, field bean,* Vicia faba, *lentil,* Lens culinaris, *yield enhancement, stature control*

INTRODUCTION

Development of synthetic plant growth regulators: Naturally occurring plant hormones are involved in the control of all plant growth and development events.

There are several endogenous hormone groups; auxins, gibberellins, cytokinins, abscisic acid and ethylene, which interact to determine the activity of physiological processes. The genetically-linked production of plant hormones can be varied by environment and these interactions result in promotion, cessation or retardation of growth and development.

Native plant hormones usually have short-lived, inconsistent effects when applied to plants and have generally not been commercially developed for improved crop performance and yield.

The most radical developments in the chemical manipulation of plant development have involved the use of chemical analogues of endogenous hormones and novel synthetic compounds. The principal objective has been to develop compounds that:

i) increase yield of specific yield components.
ii) improve plant/crop management, often in association with the use of mechanical aids to maintenance and harvesting.
iii) improve post harvest characteristics.

Clearly a major aim is to increase absolute yield or to improve the overall economic efficiency of production. With respect to improvements in yield the rational development of synthetic plant growth regulators (PGR's) has been aimed at:

i) increased net photosynthesis, with a major emphasis on reducing photorespiration.
ii) manipulation of assimilate partitioning to increase harvest index.
iii) delayed senescence to extend leaf area duration.

Unfortunately none of these processes is controlled by a single hormone or for that matter is regulated by a single gene. A conflict arises in the rational development of a PGR to influence yield-determining processes. The development of a simple PGR that mimics, stimulates or inhibits the action of a single endogenous hormone is inadequate for controlling the complex of physiological processes contributing to yield.

The increase in understanding of physiological processes is confirming the complexity of hormonal regulation, particularly if environmental and climatic factors intervene. The fact that a single PGR may only manipulate a part of the overall hormone system controlling a physiological process presumably leads, at best, to reduced or no performance, or at worst, adverse side effects.

There are virtually no examples of biorationally designed PGR's that are in commercial use. Those compounds that interfere with plant hormone production have largely been discovered by empirical methods.

The increasing knowledge of physiological processes and the controlling role of plant hormones suggests that PGR development targeted at manipulation of endogenous plant hormones is not a useful tactic. Biorational development of PGR's should be aimed first at understanding the physiology and chemistry of target processes and secondly at finding chemicals that produce desirable interference with specific enzymatic and control steps. Such an approach to PGR development should result in more specific plant responses and reduce undesirable side effects.

Triazole PGR's The triazole group of compounds that reduce gibberellin biosynthesis can have a marked effect on reducing plant stature (Dawkins, 1986).

Paclobutrazol and triapenthenol are triazole PGR's that have similar modes of action (Rademacher & Jung, 1986) but some differences in biological activity.

PGR's and grain legumes: There are few examples of PGR use in grain legume crops although the potential advantages of being able to constrain their indeterminate growth habit are considerable.

One obvious application of PGR's is the regulation of vegetative growth to prevent lodging of tall crops like field beans (*Vicia faba* L.) or to promote increased height in short stature crop such as dwarf bean (*Phaseolus vulgaris* L.) where harvesting problems, disease damage and soiling of pods borne on lower nodes is a problem.

Repartitioning of dry weight induced by PGR's may produce desirable benefits in the yield forming processes. These opportunities are discussed in relation to recent research carried on field beans and lentils (*Lens culinaris* Medick.).

FIELD BEANS

The tall stature of field bean crops, their indeterminate growth habit and their variable pod set are factors that may reduce seed yield (Newton & Hill, 1987). Spring sown crops are particularly vulnerable and yields are usually lower than from autumn sown crops in New Zealand. The contributing factors have recently been tested experimentally and the linkages between crop phenology and the environment reviewed (Husain *et al.*, 1988 a, b).

The use of PGR's to change plant stature may reduce lodging with some improvement in harvestable yield. An earlier study on field beans (Attiya *et al.*, 1983) revealed that seed yield was increased by 9.3 % and harvest index rose from 45.4 to 49.6 % following application of the PGR, paclobutrazol.

The significant increase in yield was in part attributed to higher pod production but this could not be separated from the major effects on the allocation and partitioning of dry weight, that were linked to reduced stem extension.

A later paper described a more complete analysis of paclobutrazol effects on yield promotion in field bean, (Field, *et al.*, 1989). There was particular emphasis on the formation of vegetative structures for supporting flowers and pods and a detailed analysis of direct effects of paclobutrazol on flower formation, pod development and pod retention.

LENTILS

The positive yield enhancement obtained with PGR application to field beans encouraged investigation of their effects on other grain legume species, particularly lentil.

There is considerable plasticity in the seed yield of lentils (McKenzie *et al.* ,1985, 1986) which may indicate a potential for exploitation by PGR treatments. Effendi *et al.* (1989) demonstrated some positive seed yield increases with the two triazole PGR's paclobutrazol and triapenthenol, although there were major seasonal variations in response.

MATERIALS AND METHODS

Field beans: The field bean (*Vicia faba* cv. Maris Bead) was sown on 6 October 1983 into a Wakanui silt loam soil. The experimental design was a 3 x 3 x 2 split plot with three replicates. The crop was sown in rows 10 cm apart with a precision seeder to achieve populations of 40, 80 and 100 plants m^{-2} in plots 4 x 15 m.

The three PGR treatments, were control, TIBA and paclobutrazol and plots were either irrigated or non-irrigated. Only main effect results from the control and paclobutrazol treatments are presented. There were no interactions among the variates presented.

Paclobutrazol at 1 kg a.i./ ha in 250 l water/ha was applied on 25 November 1983 to plants at the 9 leaf stage, just before flowering. Weed, disease and insect management plus details of fertilizer use and the irrigation strategy are detailed elsewhere (Attiya, 1985).

The crop was sampled at approximately two weekly intervals for analysis of dry matter accumulation by stem, leaf and pod components and for internode and stem length measurements.

Final yield was determined from harvests taken on 1-3 March 1984, both from multiple random quadrats and from a plot combine harvester.

Analysis of yield components on branches and the main stem (Table 2) was calculated from different samples to those taken for the main harvest analysis (Table 1).

For determination of flower and pod set, five plants were selected and tagged in each plot before flowering. Appearance of flowers and pods at all nodes was recorded.

Nodes 10, 13, 16 and 19 were selected and marked with wire loops and flowers and pods were counted at regular intervals to determine formation and loss.

Plants were harvested at maturity and yield components measured at all nodes. A distinction was made between mature pods with at least one fully developed seed and immature pods that had only partial or no seed development.

Lentils: The lentil (*Lens culinaris* L.) cv. Olympic was sown on 18 September 1987 into a Templeton silt loam soil.

The experimental was a 2 x 2 x 4 randomised block design with four replicates. The treatments were plant population (100 and 300 plants m^{-2}), the plant growth regulators, paclobutrazol and triapenthenol, each applied at four rates (0, 0.3, 0.6 and 0.9 kg a.i./ha), (Effendi *et al.* 1989).

The PGR treatments were applied on 11 November 1987 (54 DAS), when the plants were at the 11-12 leaf stage.

The crop was sampled prior to the final harvest taken on 5 February 1988 (136 DAS). Quadrat samples were taken for height and dry weight determinations, and yield components were determined on a sub sample of five plants.

There were no interactions between plant population and the PGR treatments. Therefore only the main effects attributable to the PGR treatments are presented.

RESULTS AND DISCUSSION

Field beans: Application of paclobutrazol did not significantly affect total shoot dry weight at final harvest (1,091 and 1,105 g/m^2, SE = 29.0).

Analysis of individual dry weight components revealed a marked reduction in stem weight which was linked to a shortening in plant height by 13.8 % (1,359 to 1,171 mm, SE = 23.3).

Shorter stature was associated with reduced internode length, particularly of those internodes formed immediately after paclobutrazol application. With paclobutrazol internodes 10, 13, 16 and 19 had a -37.7, -41.0, -21.9 and +2.2 % change in length, respectively.

The reduction in stem length may have been linked to the small but not significant reduction in the percentage of broken stems at final harvest (24.7 to 20.9 %, SE 2.55).

Previous experiments have shown a more significant effect of paclobutrazol in reducing lodging (Attiya *et al.* 1983).

At final harvest (147 days after sowing) the pod fraction in paclobutrazol treated plants contained 34.4 % of the total dry matter compared to 25.3 % in the control. This was a significant increase in harvest index.

Pods in paclobutrazol-treated plants had an increase in absolute dry weight of 37.7 % and this was the basis for a significant improvement in seed yield.

Reduced stem extension was linked to changes in the partitioning of dry weight which gave a significant improvement in harvest index. The induction of such large changes by PGR application are rare and may have been exaggerated in this instance because overall yield was lower than in other seasons (Attiya *et al.*, 1983; Husain *et al.*, 1988a,b).

Notwithstanding the low yield and harvest index, the basis of paclobutrazol-induced enhancement of yield is of major interest and involved not only a change in dry weight partitioning but also had significant effects on reproductive capacity.

Analysis of yield components of individual plants showed that all factors contributing to yield were increased by paclobutrazol (Table 1). The increase in the number of pods per plant was the most significant, increasing by 37.3 %, while the number of seeds per pod and the weight of individual seed increased by 9.5 and 6.2 % respectively.

The maximum potential increase in seed yield of 57.9 % was reduced to approximately 42.1 % because of

Table 1: Components of yield analysis in *Vicia faba* at final harvest (147 d after sowing).

	Control	Paclobutrazol	SEM	Percentage change
Pods/plant	5.1	7.0	0.20	+37.3
Seeds/pod	2.1	2.3	0.06	+ 9.5
Seed weight (mg)	354	376	6.0	+ 6.2
Seed yield (g/plant)	3.8	6.0	0.20	+57.9
Plants/m^2*	59	51	1.26	-13.6
Seed yield (g/m^2)	190	270	10.0	+42.1

* independent analysis. (from Field *et al.*, 1989)

a 13.6 % reduction in plant population which was associated with paclobutrazol application.

Effects on flowering and pod set were marked (Table 2). Paclobutrazol induced pod set at lower and higher nodes on the main stem and there was a 42.6 % increase in the number of podded nodes.

Pod retention of all pods was significantly improved by paclobutrazol, although many were immature and did not set seed. Paclobutrazol increased the development of immature pods resulting in no enhancement of mature pods on the main stem.

Paclobutrazol enhanced flowering and subsequent pod set by earlier and more prolonged flowering on the main stem, (Tables 1, 2).

Although pod retention was high and there was an increase in the number of podded nodes, this did not increase seed yield on the main stem.

The major increase in the number of pods per plant was linked to paclobutrazol-induced changes in both vegetative growth and the pattern of flowering.

Paclobutrazol increased the number of branches per plant from 0.8 to 0.9 (SE 0.09) while their dry weight increased from 4.9 to 6.7 g (SE 0.46). While paclobutrazol induced changes to pod production increased the yield potential on the main stem, the real benefits were associated with changes to branching.

Branch number was increased slightly by paclobutrazol and this may be linked to redistribution of dry weight and the reduction in main stem dry weight. Analysis of seed yield (Table 2) showed that paclobutrazol-induced enhancement was linked to a 118.2 % yield increase on branches.

The major effect of paclobutrazol on field beans was apparently developmental and the very large increase in mature pod production on branches may have related to earlier pod initiation, as demonstrated for the main stem (Table 2). Overall the positive effects of paclobutrazol seem to be more closely linked with developmental changes rather than gross allocation of dry weight.

The small but positive increases in the number of seeds per pod and mean seed weight could be associated with either factor while earlier developmental events such as the pattern of flowering and pod set are probably not linked directly to dry weight partitioning.

Lentils: Paclobutrazol significantly reduced plant height from 331 mm to 282, 284 and 249 mm (se 13.0) at 0.3, 0.6 and 0.9 kg a.i./ha, respectively, at 82 DAS. Significant height reductions were only found in the 0.9 kg a.i./ha treatment at 109 DAS.

In contrast reductions in height with triapenthenol were less marked, dropping from 317 mm to 307, 286 and 276 mm (SE = 13.0) at 0.3, 0.6 and 0.9 kg a.i./ha respectively, at 82 DAS. No significant differences were apparent at 109 DAS.

There was no significant effect of PGR's on total dry matter production, pod number, and seeds per pod. However, both paclobutrazol and triapenthenol affected ($P < 0.05$) seed yield with a maximum of 251.1 g/m^2, and of 239.0 g/m^2 respectively, (Table 3).

Paclobutrazol at 0.6 kg a.i./ha increased HI from 44.8 to 49.2 % ($P < 0.001$). It had no effect on the number of branches (Table 3).

Triapenthenol also affected seed yield and gave a maximum yield of 240.7 g/m^2 at 0.6 kg a.i. /ha (P <

Table 2: Pattern of pod formation and distribution of seed yield on main stem and branches of *Vicia faba*.

	Control	Paclobutrazol	SEM	Percentage change
First podded node	13.6	13.2	0.21	
Final podded node	19.0	21.0	0.27	
Number of podded nodes	5.4	7.7	0.29	+42.6
Percentage pod retention (125 - 147 DAS)	78.3	99.4	7.55	+26.9
Mature pods per main stem	3.4	3.4	0.29	0
Mature pods per branch	1.4	3.0	0.31	+114.3
Seed yield per main stem (g/stem)	2.5	2.7	0.20	+8.0
Seed yield per branch (g/branch)	1.1	2.4	0.33	+118.2

(from Field *et al.*, 1989)

Table 3: The effect of PGR treatment on dry matter production, seed yield, harvest index and yield components in lentils.

Treatment	Dry matter g/m2	Seed yield g/m2	Harvest index %	Branches/ plant	Pods/ plant	Seeds/ pod	Mean seed weight mg
Paclobutrazol (kg a.i./ha)							
0.0	480.0	215.0	44.76	13.6	30.3	1.17	65.4
0.3	505.3	243.0	47.51	16.1	28.5	1.08	70.1
0.6	507.3	253.4	49.80	15.3	33.5	1.12	70.6
0.9	479.5	235.7	49.15	16.8	32.1	1.14	67.9
Tripenthenol (kg a.i./ha)							
0.0	457.0	213.5	46.70	12.3	32.6	1.14	68.0
0.3	487.7	236.5	48.55	15.4	34.5	1.10	68.3
0.6	501.4	240.7	48.12	17.1	29.2	1.07	69.5
0.9	474.9	218.5	48.65	14.6	33.6	1.12	65.9
SEM	23.6	14.4	1.15				

0.05). Branch number increased with a maximum of 17.1 branches per plant ($P < 0.05$).

Under favourable moisture conditions paclobutrazol and triapenthenol increased ($P < 0.05$) seed yield/ha (Table 3). This was mainly due to a higher number of pods per plant, total dry matter production, and HI.

This was related to lower plant height and shorter mean internode length following PGR application (Table 3). Reduced height induced by the PGR's tended to increase assimilate partitioning to generative organs like pods, or supporting organs such as branches.

It is possible that the reduction in plant height and mean internode length increased the competitive ability of the pods for assimilate supply and aided seed formation.

The PGR effect on lentils was achieved in a season of adequate soil moisture and pronounced vegetative growth, (Effendi *et al.*, 1989). In contrast in a dry season with inadequate irrigation there was no effect of PGR's effects and thus no increase in yield (Effendi *et al.*, 1989).

Poor performance may be attributed to a low yield potential in the dry season or lack of PGR efficacy because of poor soil mobilization.

The experiment reported here involved a single time of PGR application at the 11-12 leaf stage. Earlier application at the 6-7 leaf stage was less effective in inducing increased yield (Effendi *et al.*, 1989).

Many of the triazole group of PGR's, such as paclobutrazol and triapenthenol are rate and time dependent in their effects on crop growth (Dawkins, 1986).

There is a clear need to understand the relationships between the time and rate of PGR application, lentil crop phenology, environment and soil factors and possible yield enhancement.

CONCLUSIONS

The use of triazole PGR's on grain legume crops such as field beans and lentils may confer significant yield and management advantages.

Commercial development of PGR treatments for grain legumes is likely to depend on the consistent demonstration of advantages.

The evidence suggests that the potential benefits of PGR application to legume crops with an indeterminate growth habit is considerable and greatly exceeds those found in other crops such as cereals (McLaren, 1982) and sugar beet (Stevens, 1985).

Chemical treatments that limit vegetative growth often increase flower production and fruit set by reducing competition for assimilates (Quinlan, 1982). In field beans the extension of flowering and pod formation to node 21 (Table 2) by paclobutrazol was a developmental advance that was not maintained to full pod maturity. This suggests either, that while initial assimilate supply was adequate it could not be maintained or that other regulatory factors were determining pod development. It is significant that other gibberellin synthesis inhibitors, CCC and B9 have been shown to increase flower set in field beans (El-Beltagy *et al.*, 1979), while in other species gibberellins have been closely linked with flower induction and fruit development (El-Beltagy *et al.*, 1979; Quinlan, 1982).

The present data suggests that paclobutrazol-induced changes in gibberellin biosynthesis may contribute positively to reproductive development that improves seed yield per plant.

Overall, application of triazole PGR's to field beans and lentils produced major benefits in seed yield enhancement (Tables 1, 3). In addition in a tall crop such as field bean there are potential crop management and harvesting improvements associated with reduced plant height and more robust stems (Attiya *et al.*, 1983; Field *et al.*, 1989).

While yield enhancement trends were also found in lentils any reduction in plant height in this crop may cause harvesting difficulties.

Soil residual problems with some triazole PGR's, notably paclobutrazol may create limitations to their use and influence of crop rotations. While no major post-crop problems have been experienced with paclobutrazol applications of 1 kg a.i./ha, or less, there are advantages in developing alternatives to blanket, post-emergence applications.

Dobson & Field (1987) demonstrated the possibility of incorporating paclobutrazol into a seed treatment at sowing. Retardation effects were pronounced and such an approach could provide a more cost-effective PGR treatment method for grain legume crops.

The experimental data presented here indicate the potential advantages of using PGR's to regulate the growth and development of indertiminate grain legume crops.

It is equally clear that yield and management benefits may be inconsistent and relate to seasonal changes in environment, particularly available soil water (Attiya, 1985; Effendi *et al.*, 1989).

Further research is required to determine optimum PGR treatments and to eliminate the unreliability of their response. The overwhelming conclusion is that under ideal conditions PGR treatment may dramatically enhance seed yield and produce benefits that exceed those typically attainable in a short term plant breeding programme.

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REPORTS FROM WORKSHOPS ON -

LEGUME RESEARCH PRESENT AND FUTURE

1. MANAGEMENT OPTIONS

Convenor - **D.R. Wilson**

There were only seven people in our discussion group so we wondered whether most people here considered that crop management is not a major problem, and that we have most of the answers already for management of grain legume crops. I don't think we agreed with that.

We felt that the main requirement for successful legume crop production is to get the basics of management right, and we discussed whether that is being achieved at present. Yields achieved by the best growers are well above the average achieved by the majority. This suggests that many growers are falling short of ideal crop management, and our first conclusion was that it is important to encourage these people to lift their crop performance. There is more scope to improve overall legume crop production by increasing yields of average or below average crops than by concentrating research and extension effort on those who are already performing well.

Improved performance requires better communication to growers of what is already known about the management needs of legume crops. This is probably more important than the need for research. Research tends to improve the top yields, with less impact on the average.

We felt that an important aim of management should be to improve consistency of crop performance. Stability and reliability of yield and quality are important for growers and marketers of the crops because risk and uncertainty in planning and budgeting are reduced. Again, this means that improvement is needed more among the majority of growers than just the top producers.

We briefly discussed likely impacts of climate change on legume crops, and we concluded that the most important undesirable effect might be to increase yield variability from season to season. If temperature increases significantly, yield potential could be reduced.

The group agreed that successful weed control is probably the single most important aspect of legume crop management. The next two priorities are disease control and irrigation management. One contributor suggested that management of harvest is often not emphasised enough; factors such as crop management immediately before harvest, correct combine setting and handling and storage of seed are very important for both yield and product quality, particularly in peas.

The group discussed the question of what limits the amounts of grain legumes grown. The main management limitation is disease which restricts the frequency of legume crops in each paddock. However, legume crops can be important for fertility restoration, and for breaking disease cycles of other crops in farm rotations. Ultimately, market signals and profitability mainly determine how much of each crop is grown. If a profitable market is available for a crop, the technology is available to overcome most management limitations.

The final topic discussed was the feasibility of soya bean production in New Zealand. We concluded that the climate is too cool in the South Island, but the crop could be a viable proposition in the northern North Island.

2. PROBLEM AREAS FOR RESEARCH

Convenor - **J.G.H. White**

We agreed that research in grain legumes should be market driven and that we really need to know much more about our markets, particularly overseas markets, if we are to plan our research effectively.

One of the merchant members of our panel pointed out that merchants keep a lot of the specific market information very much to themselves. He did, however, agree that in future there should be much greater sharing between merchants and this is an area we should explore further.

In spite of this, there is more general information available on world markets that New Zealand should somehow be obtaining so that we can plan our marketing and research accordingly.

We moved onto a discussion on funding research: where does the money come from? The feeling was that with crops like peas where there was an obvious return both to merchants and farmers, then there should be some contributions from both groups as well as Government.

For new crops like, for example, chickpeas, it would be unfair to ask farmers and merchants to fund development research entirely, if at all. There was a general feeling that funds for this sort of research should largely come from Government through regional development grants or special grants because of the importance of grain legumes in particular regions, and their general importance for human health. At the moment it looks as if these monies might be channelled through DSIR and MAF and it's up to a group such as merchants, farmers & scientists working with grain legumes to lobby for these monies for work on new grain legume crops.

In relation to market-led research, there was an example given about the asparagus industry which actually did a survey to examine market trends. They then used the results of this work to plan an industry strategy. They found, for example, they needed more product and greater productivity and they are now supporting research along these lines. The suggested analogy was that we should be doing the same in the grain legume area.

We then discussed research for the farmer on the farm. It was pointed out by a farmer that there are no data available on the areas we plant out annually in peas or lentils. The lack of this information makes it difficult to plan total yields and total production and therefore export possibilities. Somehow we need a much better way of collecting such data in order to plan our growing and marketing strategies more effectively.

We also felt that regular high crop yield was important and that research to improve yield was of greater importance than research into quality. Higher and more consistent yields is a key issue for all the grain legumes.

Finally, we talked briefly on research on added value. Earlier today we talked about added value in grain legumes and agreed that was important. We digressed a little about how people buy grain legumes in supermarkets and elsewhere and how research could help to put dollars on top of the basic price. Unfortunately we didn't have time to develop the topic very far.

Question: In relation to obtaining data on grain legume areas and yields, just how do we get the Department of Statistics to collect this information? In the last set of Agricultural Statistics, I was fascinated to discover that the only grain legume any record is kept for is peas. And yet we get records for garlic and rhubarb to the nearest 0.1 ha. It seems to me to be nonsense to have a crop like lentils that occupies nearly 3,000 ha and have no idea exactly how much is grown. Similarly there are now about 800 ha of dried beans being grown. Where do we attack the Government to get this sort of information collected?

Comment: It's a problem, but if we are to plan any sort of export trade this basic information is essential. However, there are many farmers who object to filling in more details on the Agricultural Statistics forms than they are already. That is part of the problem.

3. PRODUCTION OPPORTUNITIES AND AVAILABILITY OF NEW CROPS

Convenor - **W.A. Jermyn**

We had a wide ranging discussion on production opportunities and availability of new crops. There are plenty of possibilities, it's a matter of winding them up a bit. We wondered which one we should concentrate on. We looked at the summer legumes:- crops like Adzuki beans and mung beans that are in high demand in some of the Asian countries.

We also had a cursory examination of some of the vegetable pulse crops and Alec McErlich from Watties talked about some of the very real difficulties in processing some of these crops and we wondered if that might be a suitable area of research. After discussing things that have been tried and come to nothing, we began to focus on identifying 3 crops that were really worthwhile and we came up with the following:

1 A re-evaluation of the domestic feed market for peas and lupins as a very real opportunity. We had an animal feed manufacturer who wondered aloud how production might be enhanced because he made the comment that production of grain legumes for the feed industry is always in short supply. We will need to address mechanisms for enhancing that supply.

2 The second is the enhancement of the winter legumes, i.e. lentils and chick peas. Lentils are growing in Canterbury but they are probably not reaching anywhere near their potential and that is an area that everyone needs to address. The other is chickpeas - both *Kabuli* and *Desi* types probably have very large potential and capability of production in Canterbury. These might be priority areas for research in the future.

3 It was harder to get a third crop. We talked about peanuts, and soya beans in the North Island, given the suggestion that there's a large market for full fat soya bean that has been consistently not met for 10 - 15 years, and that traditionally the United Sstates cornbelt grows corn and soya beans in rotation. We have corn or maize in the North Island, but we do not have the soya bean component in that rotation - we ought to examine why not.

So we settled on three items as something to have another look at either as an industry or as researchers or merchants in the grain legume industry.

Question: Can I just elaborate that what we were really suggesting was rather than look at the varieties of peas which we have at the moment we should look at other high yielding cultivars so that at a lower cost per tonne, a higher yield will still have the same gross margin.

Comment: There is another aspect to the price of crops in New Zealand and that is the structure of the industry as a whole. I think that is something that industry, the farming industry and the end users, have to tackle in a positive way and look at just where the money is going in production. I think it is a major economy and some major opportunities in terms of what crops can be used.

Jermyn: I appreciate that comment. I think it is one of the major objectives that we had in deciding to hold this workshop at this time is to look at ways in which the grain legume industry in New Zealand can be improved with benefits for all the parties.

Further comment about price, the group did identify that a high yielding field pea as opposed to a quality grain pea might be a worthwhile objective. It is not something that we have strongly addressed in the past and those of us in that game will have to look at it. In the session on peas, a person said they did not care about quality, as far as they were concerned it was the number of tonnes per hectare.

RESEARCH AND PROMOTION OF THE UNITED STATES DRY PEA AND LENTIL INDUSTRY

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ABSTRACT

This paper reviews the establishment of the Washington-Idaho Pea and Lentil Commission in the Pacific Northwest of the United States. Lentils and peas are grown in rotation with wheat or barley. Average yields of the legumes are 2,717 kg/ha for peas and 1,226 kg/ha for lentils. The importance of co-operation between growers and processors working together to raise funds for appplied and market research is stressed. Promotion and selling of the crops at both the national and international level is improved by the provision of information on methods of cooking them and of their nutritional quality.

Additional Key Words: Lens culinaris, Pisum sativum, *marketing, research, utilization.*

INTRODUCTION

It is a pleasure to be asked to join you at this meeting, because in many respects, you are probably at the same point we were 25 years ago.

My purpose is to give you the background to the formation of the Washington and Idaho Pea and Lentil Commissions and how we have involved farmers, processors, and exporters into an industry-wide organization.

THE UNITED STATES INDUSTRY

I would like to begin by giving you background on our production area. All of the total commercial United States production of dry peas and lentils is located in the Pacific Northwest corner of the United States. Approximately 118,000 ha to 142,000 ha of peas and lentils are grown annually. This area has a rolling hill topography with a heavy clay loam soil. Farms comprise of 50% to , and 80% sloping land. Slopes range from 8% to 30%. Special combines with levelling devices are required to keep the machines from tipping over on the hills. The average farm size is about 325 ha. The average rainfall varies from 460 mm to 660 mm, which is sufficient for annual cropping.

The main crop is winter wheat which is planted in October and harvested in August. Peas and lentils are planted in April and harvested in August and are an excellent alternate crop for our area. Most farmers use a 2 or 3-year rotation of wheat, peas or lentils, and wheat; or wheat, peas or lentils, and barley. The same equipment can be used to sow and harvest peas and lentils as wheat. In 1989 year we had an excellent crop. Green peas yielded an average of 2,717 kg/ha over 55,915 ha sown. About 11,947 ha of yellow peas were sown.. The 38,225 ha of lentils yielded an average yield of 1,266 kg/ha. The 10-year average yield of peas is 2,107 kg/ha and for lentils, 1,101 kg/ha.

SELF HELP

I suspect that our organization's beginning was similar to what is happening in this industry. Back in the early 1960's a group of farmers got together to discuss what could be done to encourage more research and to initiate efforts to develop better markets for our products.

They soon found two things. First, there was very little being done in research and marketing; and second, they found that if anything was going to happen, it would require funds.

The local state laws provided a vehicle to set up a checkoff or tax which could be collected after a vote by growers.

In July, 1965, the Washington and Idaho Pea and Lentil Commissions were formed after a favourable vote by growers. It was anything but a unanimous vote. The law required that at least 51% of the growers must approve. A vote of 51.4% validated the referendum which is not exactly an overwhelming majority. Many growers and processors had serious reservations about the Commission approach and because of those reservations, a provision was added which mandated that every five years the growers must vote on continuing the assessment for another five years. Although the people who helped in getting the Commissions established were disturbed by this provision, I believe it is one of the strongest parts of our programme. If you cannot justify your programmes to the people who are paying the bill, then there is no reason for collecting the funds.

If government agencies operated under this law, I believe we would probably have a lot less government. Every vote since 1965 has resulted in a 90% favourable vote, so we feel that we have a vote of confidence from our growers and feel we are involved in the kind of programmes that growers want.

Funds for the Commission programmes come from the assessments paid by growers and collected by processors which are then remitted to our office. All growers must pay by law, whether they agree with the programme or not, the only exception being the American Indians. Unfortunately, we have two different assessment schedules for our two states. In Washington it is 1% of the net sale price, while in Idaho it is $US 2.56 /t on peas and $US 2.76 /t on lentils.

The assessments provide a source of funds to support the programmes administered by the Commissions. Each Commission operates on an average budget of $US 250,000.

In addition to the Commissions, I also manage the American Dry Pea and Lentil Association. This is a voluntary organization principally of processors and exporters and is supported by a membership fee structure and a voluntary assessment paid by processorsof 20 to 30 US cents /t of processed product. The Association's average budget is approximately $US 100,000.

Each organization by itself does not have a large budget. However, by pooling our resources and cooperating on joint programmes we have a large enough budget to initiate programmes which benefit the entire industry.

From 1968 to 1979 the Commissions administered the programmes from an office located in a mobile trailer. By 1978 the Commission programmes had expanded to the point where the Commissions had to look for new quarters. It was then decided that the industry should build a new office building to hold all industry organizations.

We have two grower associations which operate on budgets of less than $US 10,000. At that time the American Dry Pea and Lentil Association was operating on a budget of $US 10,000. The problem then was how to build an office building which cost $US 165,000 with assets of $US 30,000.

We decided to ask growers, processors, exporters, and friends of the industry to donate to a building fund. The response was overwhelming. Donations ranged from $US 1 to $US 1,000 with an average of about $100.

We moved into our new quarters in December, 1979, and one year later it was completely paid for. The office is now owned by these three organizations and the Commissions pay rent to them which keeps the funds in the industry.

Housing all organizations under one roof makes sense, as it cuts down on administrative expenses and more importantly, all of the industry programme can be coordinated more effectively.

In 1980 we established a sinking building fund with part of the rental funds in case we needed to expand the present office.

Last year we completed a 302 m^2 , two-story addition which provided additional office and work space for our staff. In addition it provided a meeting room that can hold up to 50 people. This spring we added a complete kitchen facility which can now be used for testing recipes and demonstrations.

The three associations now own a 1/3 interest in a $US 268,000 facility which is not bad for three organizations which had a total budget of $US 30,000.

INDUSTRY PROGRAMMES

The three basic programmes of our industry are Research, Domestic Promotion, and Foreign Market Promotion. One of the growers' first priorities was to establish a viable research programme to develop new varieties. When I first started, the pea and lentil research programme consisted of a 3 m research plot which also included such exotic crops a Cape Marigold and Crambe. We now have two full time scientists working on breeding and production problems. The programme is headed up by Dr Fred Muehlbauer who is becoming internationally known because of his research.

Last year we were able to obtain $US 150,000 from our government to add another full time scientist to our programme. This was done in spite of very tight budget problems by our government. It was the only research programme in the entire United States Department of Agriculture budget that received an increase.

Although we are not as large an industry as the wheat, soybean, cotton or rice industries, we have been able to accomplish some things that they have not because we are well organized and we do a very effective job of lobbying in Washington DC. Also, we are not just asking for the funds, we are also willing to tax ourselves to help pay for programmes. It is always easier to obtain funds when you are willing to help pay for part of the programme.

In 1986, the government banned one of the few herbicides we have available, Dinoseb. Although we were told it would be impossible to obtain an exemption after the government had banned the product, we were successful in obtaining a two-year exemption in order to initiate research to find a substitute which, by the way, we have yet to find. The peanut and soya bean industry are still trying to figure out how a small industry like ours could accomplish this. I tell them it's because we utilize our rowers to lobby rather than hiring high-priced lawyers.

One of my concerns is the recent trend by state and federal programmes to concentrate on basic research rather than applied. Part of this emphasis is due to lack of funding for government research programmes. Unfortunately, most of the funding that is available today is in the field of basic science. Applied research areas are not a major source of funds.

There seems to be a trend to put all of our resources into biotechnology, thinking it will solve all our problems. Biotechnology holds great promise for solving many food and agricultural problems, but there is a danger of expecting too much too soon. I am certainly not against basic research because it is the corner-stone that applied results are based on, but if we do not take basic research and develop a cure for cancer or develop a new pea variety, then I believe all that basic research has been waste.

We should not drop all of our applied research thinking that biotechnology will solve all of our problems and even assuming this will happen, the answers are at least 20 years away. It is extremely important that we have a balance between basic and applied research.

INTERNATIONAL CO-OPERATION

In 1986, the industry sponsored the first ever International Food Legume Research Conference. We had 400 participants from 51 countries throughout the world. It was a highly successful conference for two basic reasons. We had some very competent and dedicated researchers who organized and put the programme together and secondly, the pea and lentil industry was an integral part of the project from the beginning. The industry was also able to provide funding to initiate the conference, although the majority of the funding for the conference came from government and international organizations.

Out of the conference came two recommendations. First, that another conference be held in four or five years; and secondly, that the United States establish an international research programme to network with all the other national and international research programmes throughout the world. The next conference is now scheduled for Cairo, Egypt in 1991, and the industry has now developed a proposal to establish a Cool Season Food Legume Research programme for peas, lentils, chick peas and faba beans. We have established an annual budget of $US 1,500,000 for the programme and are now trying to obtain government funding. It is essential that we establish a programme which will cooperate with all research programmes world wide so we can share information and avoid duplication of efforts, which will benefit everyone. Scientific knowledge should be shared.

Industry needs to be a partner in any research programme in order to give direction to researchers so that they are addressing the right problems. Industry needs to prioritize its problems for researchers. We really can not criticize a researcher's programme unless we tell them what problems to address and equally important, unless we provide them with the funds to find the answers.

We have established an industry review panel whose primary objective is to determine the major problem areas that should be addressed by researchers and to prioritize and recommend to the Commissions what projects should be funded.

INCREASING DOMESTIC SALES

I have always felt that the future of our industry lies in developing the domestic market for our products. It is difficult to compete with Canada, Turkey, Australia, and New Zealand when many of these countries have lower production costs and, in some cases, are closer to export markets.

In the United States the domestic market is virtually an untapped market with many parts of the United

States unfamiliar with our products, particularly with lentils. We are making progress, as the domestic consumption of lentils has gone from 1,360 t 25 years ago to 16,780 t last year. We have a full time domestic marketing director and we feel our advertising and promotion programmes are finally getting results.

One of the first things we found was the complete lack of recipes which we set about developing, and which we continue to do today. We are now in the process of publishing a 200 page recipe book.

In addition to developing recipes for the consumer, we also provide volume size recipes for schools, restaurants, hospitals, and other volume feeders. Last year we hired a chef to put on a series of demonstrations in the large cities for food editors and up market restaurant chefs to convince them to add peas and lentils to their menus.

The consumer of today is more nutrition conscious than ever before. We have a product that is just what the consumer wants. It is high in protein, low in cholesterol, high in fiber, convenient, and inexpensive.

In the past few years the Commissions have concentrated on advertising in the institutional area, as we felt that we could get more increase in market volume for the funds expended. We advertised in major institutional publications as well as providing,free of charge, volume size recipes and merchandising aids such as table tents, place mats and nutritional information to stimulate interest in trying our products. Promotions such a National Split Pea Soup Week and National Lentils for Lent help publicize our products and aid in securing a lot of free publicity.

In 1980 we formed another organization called PALS, which stands for "women associated with the production of peas and lentils". This is a voluntary organization of grower wives which was organized to help the Commissions with local promotions. We find they are our most aggressive salesmen. They are not only enthusiastic but sincere, because it is their livelihood and they do a terrific job of selling our product and industry. We now have about 100 ladies who volunteer their time and the Commission pays all their expenses. They now staff all of our national exhibits and handle our supermarket demonstrations. They are currently putting together a 200 page pea and lentil cookbook which we plan to market nationally in book stores throughout the United States

Domestic promotion and advertising is a long term programme which we feel is finally beginning to pay off. Domestic sales of peas were up 23% last year and lentils were up an unbelievable 60%.

EXPORT PROMOTION

Since about 75% of our production of dry peas and lentils is exported, export promotion is an important part of our programme. The price of our products, to a large part, depend on what the current export situation is; and the more customers we have for our products, the more favourable the price.

We currently export to over 50 different countries throughout the world, and that is why foreign market promotion is such an important part of our programme. While the Commissions handle our research and domestic promotion, we have set up another organization to handle foreign market promotion.

The USA Dry Pea and Lentil Council is responsible for directing this programme. The office operating budget is provided by the Commissions and Associations. The Council is then able to take advantage of United States Government funds for our overseas promotional programmes. All of the Government funds must be spent overseas. We currently have advertising and promotional programmes under way in India, Japan, Pakistan, Spain, Sweden, and the Philippines. We also have offices in India, Japan and Spain and will be opening an office in Pakistan in December 1989.

In addition to trade servicing of regular customers, we conduct marketing studies of potential new markets. The United States was the first to open up the Indian market which is now serviced by Australia, Canada, Hungary and New Zealand, as well as the United States

Another successful programme has been to sponsor trade team visits to the United States to acquaint them with our industry and products. These teams represent importers, government officials, canners, and other end users of our products.

We were able to convince Taiwanese vermicelli manufacturers hat Austrian winter peas could be used to produce an excellent quality, transparent noodle which is popular in the Far East.

CONCLUSION

I have tried to briefly outline some the programmes that our industry has undertaken. The dry pea and lentil industry is no different from any other business. In order to be successful, we must be aggressive, to maintain our current markets and expand into new markets.

I feel that the Commission assessment should be considered as an expense item to the farmer rather than a tax. The average farm in the United States has more capital investment in land and equipment and utilizes more capital than most businesses in the city. If you look at some of the large companies, you will find that the most successful firms are those who devote a large share of their budget to two items: research and advertising. Those companies who remain on top are the companies who have the strongest programmes in these two areas.

How much of the farmers' operating budget is now spent on research and advertising? Assuming that he did set aside funds for research and advertising, how much would he be able to accomplish by himself? However, if you got together with your neighbours you would have enough funds accumulated to do some good. This is essentially what we have done with the Commissions. We are the research and advertising arm of the farmers' business.

In order to have a successful programme, you must be aggressive; and in being aggressive, you will make mistakes. The only sure way to not make any mistakes is to do nothing. The important thing is to learn from your mistakes.

Sometimes it helps to not be real smart. When someone says that something can not be done, we are so dumb we just go ahead and try anyway and in many cases we have been successful. If we were real smart, we probably would not even try.

There is strong competition between members of our industry and that is a healthy situation just as we welcome competition from Canada and New Zealand. Even though we compete among ourselves, it is extremely important that we communicate between various phases of our industry and, I believe, the same spirit should apply to the United States and New Zealand in regards to pea and lentil markets and research.

While I realize that we must be competitive in world markets, I believe it is important to keep prices at a level where growers of both countries can make a profit. Tractors, combines, and chemicals cost more each year be it New Zealand or the United States, and it is important that as the cost of production goes up, our price levels reflect these increases. Let's not make the mistake of getting price levels so low that none of us can make a profit.

I appreciate the opportunity and invitation to appear on your programme. I would like to issue a special invitation to each and every one of you to visit our area at any time. Thank you for the opportunity to appear on your programme.

COMMODITY LEVIES

Nicky Jenkins

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Quite a few farmers visit Wellington from time to time - and not only the farmer politicians who have to be there. I heard about one the other day who, when he'd been walking up Featherston Street with his wife, was approached by a pretty scruffy individual who begged 20 cents for a cup of coffee. The farmer thought about it then forked out the money. His wife was furious - telling him in no uncertain terms that he'd been conned. "Maybe you're right," the farmer said, "but the point is I'm going to follow him - maybe he really does know where in Wellington you can still get a cup of coffee for 20 cents."

That story, it seems to me, gives you a pretty good picture of how farmers are likely to react to commodity levies.

There are a number of relevant points. Firstly, the farmer had some money. Not only did he have some money but he was prepared, under certain circumstances to be parted from it. Secondly, he wanted value for his money. Thirdly, he wanted results. He wanted to see for himself that there was a good deal to be had, and, more importantly, that he wasn't being conned.

Maybe the story didn't end there though. It's to be hoped that if he found the coffee he did at least spread the word to other farmers.

There are a number of parallels with commodity levies. From discussions underway in the arable industry now for some years, it's obvious that farmers are prepared to make money available for research as the Government's contribution reduces, but first, need to be convinced that the research is appropriate, will benefit the farming industry, and is cost effective.

Farmers must also be closely involved in the decision making process: setting of priorities, allocation of funds, analysis of results and, not to be forgotten, the distribution of the resulting information. Words such as accountability, transparency, targeting may well be current jargon, but they must be part and parcel of the system before farmer funding will proceed.

In the arable industry debate on the need for funding has continued ever since the Lange Labour Government decided to create a new environment for science funding. On this issue, as it has on a number of other issues, the arable industry has been ahead of other sectors of the economy. The possibility of introducing an Arable Crops Levy Bill was taken up with Government five years ago. But calls from other agriculture based organisations for a similar levy led MAF to promote a Commodities Levy Bill instead. The idea of this Bill was to provide not only an umbrella structure for levies on individual arable crops, but a method by which any primary industry commodities could be levied, if a majority of the producers so wished. This idea was so successful that other industries wanted to cash in, cement makers for instance. Great for those industries as a means of safeguarding their funding, but a cause, in the meantime, of major delays to our legislation, and major problems for some arable crops.

I'll come back to the Bill itself later. First let's look more closely at arable commodity levies. They have been in place on a number of crops for some time. Wheat, maize and herbage seeds had or still have levies in place.

Some of the levies have worked well, some not so well, and it's useful to look back briefly and see what can be learned for the future.

Compulsory levies exist on wheat and a voluntary levy on maize.

Herbage seeds are included because a levy existed until 1989 which growers have already agreed to reinstate once legislation is available later in 1990. A degree of cross subsidisation exists in the form of a small grant to maintain the Pulse Committee.

From my own perspective, with an administrative involvement in the three industries, it seems to me that the more effective and influential levies in the past have been the voluntary levies collected by the Herbage Seed

Growers. Prudent use of the money raised by the levy quickly increased the influence of growers in the industry.

The levy provided funds for the New Zealand Seeds Promotion Council. As a result growers have equal representation with the Seed Trade and DSIR Grasslands in an organisation responsible for promoting New Zealand seeds on targeted markets at home and overseas. It provided funds to administer the growers own organisation, the Herbage Seeds Growers Sub-section of Federated Farmers, enabling growers to speak with one voice on industry matters.

Finally it provided for investments in plant breeding, in return for which growers were given a greater say in the management and direction of the plant breeding carried out by DSIR Grasslands. With Government moving to significantly reduce its funding of DSIR, a move to fund plant breeding was seen by growers as essential to guarantee the continued existence of Grasslands, whose pool of expertise, and world class facilities were a major advantage to New Zealand seedgrowers.

In all of this the existence of the Official Seed Testing Station at Palmerston North proved a significant benefit in facilitating the participation of all growers. As a central processing point for all seed lines all growers were involved and administration costs were kept to a minimum.

Although it was initially successful in meeting the objectives of growers, the levy finally failed because it was voluntary. The Sub-section had no legal power to deduct the money and was entirely dependent on the goodwill of growers to continue their support. Obvious and appropriate you would say, but in times of economic hardship, despite a low rate, the levy was too easily the subject of pressure from other sectors of the industry who saw increasing grower influence as a threat. Ironic really, that it should fail when Government and the Opposition have continually advocated voluntary, as opposed to compulsory levies, as the preferred system though I've yet to notice a move to voluntary taxation. Faced with legal requirements which would have resulted in substantial benefits to free loaders, the sub-section has abandoned the levy until such time as legislation for compulsory levies in in place.

The lessons from this? A need to balance the disadvantages of compulsion: the danger of reduced accountability and reduced relevance, with the vulnerability grower organisations face under a voluntary system, especially where the possibility of free riders exist and can be exploited. The benefits of a central collection point were also obvious.

It's interesting now to compare the wheat industry as it was until relatively recently. Totally regulated for 50 years, not only were prices for wheat, flour and bread controlled, the Government also provided for a range of grower levies for administration of the grower organisation, economic analysis, research and insurance. Research levies were compulsory on all sectors of the industry, and not only were they compulsory, they were paid automatically to Government research establishments. Flour millers and bakers levies funded the work of the Wheat Research Institute, growers funds assisted in meeting the expenses of the wheat breeding work at Crop Research Division. I think it's fair to say that, although levy collection was easy and efficient, in neither case was the resulting research work entirely satisfactory to the individual participants, nor did it totally succeed in meeting the needs of the industry as a whole.

The funds were politically initiated, politically guaranteed, and politically perpetuated, and sectors, although nominally in control of their own money, in fact were in danger of appearing largely irrelevant when it came to decisions on expenditure.

All three industry sectors were represented on the Wheat Research Committee, but so were Government advisers, merchants and other Government appointees all of whose views had to be taken into account when setting policy. The result was a great deal of frustration. Growers, in return for their funds, had good informal contact with Crop Research Division, through the Wheat Breeders Liaison Committee, but limited formal representation via the Arable Section on a Cultivar Advisory Committee, again shared with merchants and Government appointees. Wheat growers were sure there was room for improvement.

The problem of vulnerability and the free riders had been overcome, but in the process the principles of true accountability to the providers of the funds had been largely lost.

With deregulation, followed by the introduction of new legislation earlier this year, there have been major changes. However, the transition was pretty traumatic and served as a real reminder of the problems that occur with voluntary levies.

For one year, 1987, there was no legal backing for the grower levies. Again there was a certain degree of non-co-operation from the grain trade and the result was a collection rate in the region of 40 %. Free riders were the main beneficiaries. Happily the legislation was quickly reinstated and, as I said, major changes are now apparent.

Already the difference is remarkable. An industry liaison committee has replace the Wheat Research Committee. Representation is limited to Flourmillers, Bakers and Growers and although it is early days, already the focus is different and the potential for sensible industry investments greatly increased.

Grower funds, although still compulsory, can now be allocated as the growers choose, as can those of the bakers and millers.

Growers have decided to contract directly with CRD for specific plant breeding work and are now in the process of finalising contract terms which will guarantee accountability and their close involvement. Bakers continue to work with the Wheat Research Institute, but millers, with access to more than adequate milling research overseas, have chosen instead to provide additional support to plant breeding. From the growers perspective this is a welcome demonstration of the commitment of both millers and bakers to the New Zealand industry.

Maize levies too are voluntary, and collected from a relatively large proportion of the crop, but at five cents per tonne provide insufficient funds for any research, the activities of the Sub-section are limited to co-ordinating work to reduce the cost of production and promote the need for a domestic maize industry.

For these crops, farmers have shown a willingness to provide funds when the need arose. But what of the future, the other crops on which levies have never been collected. Pulse crops for example, can pulse growers be persuaded that their contribution is essential if research work is to be done? And is it essential? To what extent will Government remain involved in science funding? Let's take the last point first.

A large number of people here have their salaries largely met from the Government science budget. You will all be only too well ware of the changes that have taken place and continue to impact on research establishments. The formation of a Ministry of Science and Technology; the establishment of a Science Foundation; the reduction of Government funding by at least 30 % over the last three years; determination that 50 % of Government funds will continue to be guaranteed for basic research while the remaining 50 % becomes contestible among all sectors; and of most importance in this case, the expectation that industry will increase its involvement, particularly by way of funding.

The Government has made it clear that it is most likely to help those who are prepared to help themselves, if farmers are prepared to invest in research projects relevant to their industry, then Government, too, is likely to continue with some support. But what we must remember is that when it comes to contestible funding it won't just be arable crop against arable crop but the agriculture industry in competition with high tech electronics, manufacturing, and energy industries, to name but a few. The answer to a successful approach to the Science Foundation will obviously be preparation, organisation and co-operation to ensure that the best case possible is presented.

So, apart from its efforts to get the umbrella legislation in place, what else are arable farmers doing? The umbrella legislation is really only the start, it simply gives the ability to act on a mandate from growers of the crop concerned. Each arable commodity group will need to canvass its growers, identify the areas where research is needed and convince them of the need for funds. It's not likely to be a particularly easy task.

Perhaps the first point to bear in mind is the cynicism developed by many farmers. They remain unconvinced that the financial hardship experienced by the rural sector has been matched in other sectors, and particularly the scientific sector. When commenting on the farmer and the cup of coffee I was tempted to suggest that the lack of immediate trust that the beggar was telling the truth also had parallels when it came to farmer funding of research. For a while it did seem that scientists assumed that whatever money was withdrawn by Government would automatically be replaced by the industry. That their life would continue as normal. That would certainly only be the case, now, in the overwhelming evidence of justifiable expenditure and a worthwhile return on investment. In return for funds farmers will demand information, involvement and a return on their money. The more likely scenario is one where research efforts continue to be refined and more closely targeted as industry needs are more clearly identified. Increasingly close liaison will be required as cases are developed to take to farmers as grounds for a levy.

The second point has to do with compulsion. What is the difference between a compulsory levy and a tax? Many farmers see it as simply another form of tax and need reassurance that levies really are worthwhile. From a purely selfish point of view a compulsory levy across all crops would undoubtedly be the easiest system. It would keep the administration very simple. But it would most definitely not meet the requirements of the farmers, and would not always be in the best interests of the industry. What farmers want, and what they should be able to get under the proposed Commodities Levy Bill, is the ability to apply levies only to those crops where research is needed. The result is likely to be a variety of levies applied in a variety of different ways, administered by a small number of farmer groups under an umbrella research committee established by the Arable Section of Federated Farmers. All of this will take time to get under way. Which brings me to my third and final point.

The industry has been talking commodity levies for more than five years. Government finally accepted the concept of compulsory levies at least 18 months ago. What progress have we made since then? The answer is, very little. Delays in the legislative process now mean it is unlikely that the Bill will become law until next year. Any delay next year will bring it up against the election and a possible change of Government. Any new government will have higher priorities than commodities levies and lobbying for inclusion in the legislative programme will have to start all over again. Even when the legislation exists it will take time to gain the necessary grower approvals and put the required structures in place. We could still be well over a year away from the guarantee of funds, and, when you take the harvest into account, maybe 18 months from any available money.

But farmers do recognise the need for research and research funding. They can undoubtedly see the need for that cheap cup of coffee, but despite all the good intentions it may well be quite a while before even the 20 cents is guaranteed.

AN EXPORTER'S VIEWPOINT

B.J. Davidson

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Ashburton, Canterbury

During this conference we have heard a glossary of terms. The fact is that marketers are the main ingredient in final price levels, therefore essentially what this conference is about is are we effective, if not why and what are the alternatives. The pulse industry must be market-led, the direction must come from the marketers, who through their own performance will generate ongoing research and production.

Whilst not intending to reinvent the wheel as far as you are concerned, it is important that if exporters and marketers are going under the microscope those doing the reviews must have a detailed knowledge of the subject they are studying.

My intention is to firstly go over the various roles played in the export of New Zealand pulses today, to analyse the return that each sector obtains and to look to which countries (present and future) make up our major markets and finally to look at the system we have for the assembly and export of pulses and consider one or two possible alternatives.

Table 1 shows the main players in the export of pulse grains and their main concerns. Table 2 indicates for each dollar that is earned from the sale of pulses how much of it is retained by each part of the processing and export of the crop.

I have covered this ground because as researchers, farmers or other industry people you need to know or understand the workings of the export system if change is being contemplated.

Our current and estimated future major markets for pulses are shown in Table 3.

With reference to Table 3 two factors should be considered carefully and we should be ever mindful of them in the context of the export of pulses.

1. The ability of our trading partners to react to a state of events.
2. The lack of product marketing opportunity.

These factors are very important when considering exporting/marketing alternatives.

Table 1 The players in New Zealand pulse exports and their major concerns.

Parties (After Harvest)	Concerns
Producer	Market driven
	Quality
	Contract reliability
Carrier	Reliability
	Cost
Processor	Efficient (Cost & Quality)
	Ease of handling
Banker	Cost plus
	International
MAF/SGS	Available
Exporter	Communication
	Supply
	Shipping
Overseas Agent	Commission
	Communication
Buyer	Volume
	Performance
Shipping Company	Port Dispatch
	Cost
	FCL
Exgo	Insurance
Researchers	Seek information
	No assumptions

Putting Europe to one side for the moment, our strong markets are in the immediate Pacific Rim and the South East Asian basin. We must remember that we are trading with people who have been very, very successful at trading for decades and secondly the old adage product versus commodity. Whilst people have repeatedly spoken regarding product versus commodity, branded products and distribution networks in relation to pulses, particularly dry peas, I do not accept this rationale.

Table 2. The return from pulse exports.

Party	Per-cent return
Grower	53
NZD	3
Dressing	5
Loss	2
Sacks	3
Grading/insurance/ Exgo/storage	3
Cartage	3
Commission	6
Bank	2
Freight	18
Commission	2

In the case of pulses, with the possible exception of frozen consumer packaged product, we must approach with a commodity mentality and no amount of arguing to the contrary would convince me otherwise. Almost without exception the products are exported either in bulk 25 kg or 50 kg packages to manufacturers or repackers. Perhaps my thoughts could be better summed up if you had a one metre graph with a product, say for example tooth paste at one end and at the other end a commodity, for example oil. Dried pulses would fall into line far closer to oil than tooth paste, with frozen volume product being on the tooth paste side of oil as I consider them slightly more a product than pulses.

Table 3. Current and projected future major buyers of New Zealand grown pulses.

Year	1989	1992
1.	Indonesia	India
2.	Belgium	Indonesia
3.	United KIngdom	Thailand
4.	India	Malaysia/Singapore
5.	Netherlands	Belgium/Netherlands

With the knowledge that change will be the most constant factor, now and in the future, we must constantly improve our quality of service and re-examine our operating strategies.

In my opinion there are three basic ways New Zealand trade could look to export pulses.

1. ***Controlled assembly:*** Under this system export markets would be assured a constant supply of product within the context of dried pulses versus farmer alternatives and certainly the freedom of choice would still be governed by this factor. Whilst you probably never considered this, in fact frozen product is grown under this type of system.
2. ***Total control:*** This form of exporting and industry control has been considered in the past and no doubt will be considered in the future. I personally do not favour it as there is no firm yardstick to performance.
3. ***Status quo:*** This system allows total freedom of choice both from the grower and exporters point of view. Unquestionably it is a system that we as New Zealanders operate best under. There are certainly some disadvantages as it lacks true market leadership owing to the speculative nature of business.

Under the present system of producing pulses, growers effectively have four choices. Firstly to grow or not to grow, secondly, the options under which they can grow, that is fixed contract, pool or on a free basis. Alternatively exporters have their opportunity to choose at what level and when they wish to take a position in a market. Most certainly if I had to go through and list the the frustrating things of our role, first and foremost I would have to say the performance of other exporters, but who is to say on the day when we or they place a sale, who is right and who is wrong. Whilst many of you no doubt would be a little disappointed that I elect for the status quo, I certainly would support far greater cohesion within the industry, but this could only be achieved if all of the parties firstly accept and respect the roles that each plays and secondly the respective groups accept competition for what it is, that is competition.

In consideration of research, I believe first and foremost it must be commercially and viably placed. To this end, I personally favour the format that our company operates under and that with our peas being handled under the auspices of a separate company, the funding is effectively grower provided and in the case of Mair Seed, we also play the role of grower in contribution of funds. Conversely the return that research provides through better agronomic material and royalty returns, is also grower shared. Alternatively, exactly the same opportunities are available to those organisations with their own funded research programmes.

Researchers, I believe do have a product to sell, that is their own abilities. Those involved in research must be prepared to get out, listen to the market signals and in turn respond by marketing the advantages of your research in a quantitative form.

To the future I would look with a trace of concern wise, to events in Eastern Europe, in that at present, they have become one of our main competitors in many markets with inferior product, but clearly have the scope, given time, to produce material more in keeping with our own quality. To counter this I would call for greater cohesion within the New Zealand dry pulse industry, particularly in the production and assembly area, but would not support mandatory controls of any form.

FARMERS' VIEWPOINT

R.E. McDowell

Mayfield, R.D. 5,
Ashburton.

I was asked to prepare a paper on the Farmers' Viewpoint at a Grain Legumes Seminar and I thought, well that shouldn't be too bad. I've grown peas for about 20 years and lentils for six years so it shouldn't be too bad saying something about that.

It was some time later and much nearer the time to present my words of wisdom that I found the session at which I was to speak was headed *"The Unification of Marketing Production and Research into Grain Legumes"*.

My immediate reaction at seeing this title with all those long words was to shudder and say "This is way out of my field".

This I would suggest is quite a valid comment especially when you consider the definition of a farmer.

You may have heard the definition "A farmer is a man outstanding in his own field". Well my fields are 100 km from here at Mayfield on some Lismore and Ruapuna very stony silt loams.

I felt the best way I could approach the subject was by looking at why we grow grain legumes or pulses, what it would take for us to grow more and what effect the unification of marketing production and research would have on that. Actually, I had trouble with this word "unification".

My original thought was that this symposium was proposing to look at the possibility of combining marketing production and research into one super single desk operation that controlled all.

I didn't think this was on, politically or commercially, so like an enthusiastic amateur debater I rushed to my dictionary to find a definition I could support. I found that unification could mean bringing together or interconnection and coherence of parts and I thought, yes, there is merit in establishing greater coherence between the parts of the New Zealand grain legume industry.

I tried to obtain some statistics on New Zealand production of grain legumes so that I could get a greater feel for how the industry operates and immediately found one of the difficult areas that could be improved. The Statistics Department provided me with figures on growing areas from the Agricultural census. Knowing how farmers detest this survey and having to fill it in myself, I am somewhat skeptical of its accuracy.

MAF run a comprehensive survey which is useful for showing changes in areas of production.

The six years from 1983 to 1988 would have been some of the most volatile faced by arable farmers.

The Statistics Department figures showed that the total area of the main arable crops such as wheat, barley, peas and herbage seeds varied by about 32 %. However, the area in individual crops showed much greater fluctuations, for example the area in peas in 1987 was 53 % higher than the following year and 71 % higher than 1984.

The MAF figures show fluctuations in the different types of peas within this, e.g. the 1986 Marofat crop was only 60 % of the area of the previous crop while Maple and Blue Pea areas doubled.

These figures show how quickly arable farmers can change variety and/or crop in their efforts to grow what they perceive the market wants.

These changes must make it difficult for breeders trying to supply varieties for future needs, for those trying to predict seed requirements and traders trying to plan market strategies.

Why do we grow pulse crops? Short answer - for profit. Pulse crops have been grown as break crops in rotations and have been considered by some as a restorative crop or as a non- depletive crop to extend a rotation before sowing back to pasture. In these situations farmers were prepared to accept a small gross margin because of the value they put on these other advantages.

However, the arable farming downturn has meant that every crop grown must justify its inclusion and its expected gross margin and other considerations have been secondary.

Most farmers consider grain legumes a higher risk crop than, say, cereals. At a field day last week a farmer commented that every four or five years he finds he doesn't know as much about growing peas as he thought. This comment found general agreement amongst the group.

Pulses are also considered to be more volatile in price than many other crops. These risks must be built into expected gross margins. The greater need for security of income has caused many farmers to reduce their areas of pulse crops and/or turn to fixed price contracts rather than pool or free selling.

What would we require to see for an increase in production? Higher more consistent prices; higher more consistent yields; better disease control; more market information. Easy to say but how achievable are these objectives and would a greater interconnection and cohesion between the main players help.

When we consider marketing the crop there are two aspects. Grower selling to merchant and the merchant selling on a world market. Growers, I believe, are well served in the options they have in selling their crops. In Ashburton for instance I have at least eight companies wanting to handle my crop. I also have a range of price setting mechanisms such as fixed price contracts; indicator price contract with a limited market float; fixed price contracts locked to an exchange rate; pool contracts; free price. Many of the merchants offer more than one option.

It is more difficult for a grower to determine whether his crop is being marketed to his and New Zealand's best advantage in the world market. Pulse or grain legume prices have always been volatile and this can mask the effect of a marketers efforts.

It may seem ironic that the USA, regarded as the land of capitalism and free enterprise, can see benefits in co-operation and promotion of grain legumes. I believe the reasons that make that co-operation useful in the USA would also apply in New Zealand.

For example when lentil growing was being established in New Zealand, the two companies responsible co-operated in a joint venture called Lenzed. It would be fair to say lentils would not have developed as quickly without that co-operation.

Both of the companies went through mergers and under their new structures the joint venture was dissolved.

In the final stages both companies were marketing their own product in consultation with the other. One of them was selling into Mauritius, the other was selling little. The second company decided to also offer lentils into Mauritius. The importer responded by lowering his offering price to try and play one company against the other. The second company withdrew their offer thus preserving the price. I doubt whether that kind of consultation exists now.

More recently I heard from several sources that a New Zealand company was approaching balance date with a stock of peas on hand. It was a subsidiary of a large conglomerate which placed the company under pressure to show some cash return in the current year. The company responded by unloading their stock at a discounted price on what was a rising market. While that action had no immediate effect on growers returns, it would not have helped to raise the profile of the New Zealand grain legume industry as a reputable and consistent supplier.

Greater co-operation in disclosure of stocks on hand such as practiced by the ADPLA may have imposed a discipline which would have lessened the likelihood of that kind of sale.

I look with envy at the independent information available to the Australian farmers with publications such as the fortnightly *Grain Market Review* put out by the National Grain Exchange giving market updates and analysis of the information available to the American grower from the ADPLA with current and historical figures for production, prices and export markets based on information supplied by merchants and the USDA. Compare that to the situation in New Zealand.

We don't even know what we produce. The Statistics Department releases figures about two to three years after the event. Merchants keep their figures closely guarded as sensitive information.

MAF carry out a comprehensive survey of arable farmers, e.g. in mid-Canterbury they survey around 290 farmers, which is more than one third of all arable farmers. MAF contact them twice a year to determine planting areas and subsequent production. Wheat is split into 20 varieties, barley into 12 varieties and peas into six types. The survey is a wealth of information but little use appears to be made of it. It indicates trends rather than total production because there is little total production data available to set conversion factors. It is currently being reviewed.

There is a definite need for the survey. It needs to be related to total production. Crop areas sown need to be released in early November so farmers and merchants can make informed selling decisions. The results need much wider distribution and would probably benefit with some analysis accompanying it. Some merchants publish infrequent market newsletters. Most farmers regard them as not independent and therefore perhaps having some bias.

New Zealand has probably a unique position in world trade in that it can respond to opportunities arising from fluctuations in the Northern Hemisphere crop by planting spring crop, harvesting it and putting it on the world market before the following Northern Hemisphere harvest.

To do this we need a greater flow of information to our growers of world and New Zealand production and prices than we have at present. To try and achieve this, Federated Farmers three years ago set up a Pulse Growers Committee and a Pulse Liaison Committee to liaise between growers and the pulse traders of the G & STA. This was supported at the time by the G & STA in the face of an attempt by the Vegetable Growers Association to collect a levy on field peas. Once this threat was forestalled and the G & STA saw farmers could see advantages in such an organisation it effectively scuttled the Liaison Committee. The Pulse Growers Committee still exists but sees little it can achieve without funds.

Growers, when asked what research priorities should be, invariably placed breeding for better yields, quality and disease resistance at the top of the list. This would apply to pulse crops as much as wheat.

Growers would regard mildews and Aphanomyces as their major disease problems with peas seed bore mosaic virus resistance as important in reducing the discount New Zealand peas receive in the market.

However, I would sympathise with a breeder who was trying to determine what the long term requirements of this industry are when production is so volatile and there is little co-ordination and no forum to seek a consensus of industry requirements.

Nicky Jenkins has spoken on the Federated Farmers Arable Section's aims in seeking a Commodity Levies Act.

If the industry or, perhaps more particularly, the growers felt there was merit in unifying the sectors of the industry, the ability to levy would be pivotal to achieving that.

I do not see sufficient agreement being reached amongst the merchants for them to be able to foster the formation of some sort of New Zealand equivalent to the ADPLA. I would expect some merchants to be opposed to the concept. The initial steps would therefore have to come from growers. It is now however a *fait accompli* that this would happen.

Growers would have to be convinced that such an association would be worthwhile and would have advantages reflected in the profit they make from their crop. They would need to be sure in their minds that it would be worth deducting a levy from their crop. Those opposed to the concept would have the right to try and convince them otherwise.

However, if sufficient growers were in favour of the concept and funds were collected so that an organisation was established, I believe that those merchants who may initially show some objection could be convinced of its value. This would be more likely to happen if they could see benefits to themselves from funds made available for market promotion etc., e.g. herbage seeds.

There may be value in promotion such as this because it would appear that most New Zealand crop is sold to traders rather than end users. For example, Mauritius is an important market for our lentils. I had wondered how a small island of around one million people consumed so many New Zealand lentils. I was informed recently that some European users of lentils sourced them from Mauritius. If this is the case it would make sense to promote our lentils direct to the European user and capture a greater margin for ourselves.

If there is merit in seeking greater unification of the grain legume industry, and I believe that there is, is there any way that it can be achieved without having to establish an organisation, or a funding base from levies?

At this stage I cannot see one. Federated Farmers attempted to three years ago. On that occasion within a few months of being formed one of the parties disagreed with the other and walked away.

The only way I can see the parties retaining their commitment is when the organisation is financially independent and all can see benefits in retaining membership.

A GOVERNMENT RESPONSE TO RESEARCH FUNDING

M. Theron

Establishment Unit
Ministry of Research, Science and Technology
Wellington

Thank you for the opportunity to speak to you tonight.

I am pleased that members of the scientific community are showing so much interest in the reforms of publicly funded science and technology which the government is implementing.

The new regime is intended to refocus the attention of science and technology on the external environment. In doing so, it builds on the cost recovery moves that have already occurred in the major publicly funded science agencies such as the DSIR, MAF, MOF and the Research Associations.

There are four key elements of the new regime:

1. A focus on outputs rather than inputs; a renewed attention to what science and technology can achieve rather than how much resource it needs.
2. The introduction of contestability in research, science and technology funding so that there is a renewed focus on doing better with the limited resources that we have.
3. A renewed stress on the importance of partnership between the private and public sectors in achieving the best research, science and technology result; a recognition that neither sector can achieve as much separately as they can achieve together.
4. The development of a forward looking and cohesive research, science and technology policy to bind all of the other components together.

The particular role of the Ministry of Research, Science and Technology in all of this will be to provide the essential cohesion that science has lacked in the past.

The reforms were prompted in particular by two reports. The first was that of the Working Party chaired by Sir David Beattie. Their report, called *Key to Prosperity: Science and Technology*, lead to the formation of the Science and Technology Advisory Committee (or STAC). STAC in turn released a review of government-funded science and technology, called *Science and Technology: A New Deal.*

The government, in response to these reports, established a new Cabinet Portfolio for Research, Science and Technology, and an *Ad Hoc* Cabinet Committee of Research, Science and Technology, the Ministry of Research, Science and Technology, and the Foundation for Research, Science and Technology.

The *Ad Hoc* Cabinet Committee for Research Science and Technology comprises the Ministers of Agriculture, Commerce, Conservation, DSIR, Forestry, Education, Health, Transport, and Statistics, chaired by the Minister of Research, Science and Technology.

The Cabinet *Ad Hoc* Committee will assess national priorities in science and technology investment, and recommend budgets to the Cabinet Economic Development and Employment Committee. The primary role of the Ministry will be to provide advice on research, science and technology policy. This will involve the following elements:

1. National priorities for science and technology activities, and the level of funding to achieve the outcomes wanted by government.
2. The total level of government investment in research, science and technology.
3. The level of funding available through the foundation.
4. The quality of research, science and technology effort, so that excellence can be identified and encouraged.
5. A broad range of other government initiatives aimed at encouraging community and industry involvement in research and innovation.

The task of determining priorities will be a major area of work for the new Ministry. It is a task which will demand a high level of consultation and interaction, with the whole range of affected and interested groups in the community. Priorities for government outcomes and outputs will provide the planning basis for the Ministry.

The new Foundation will be a legally independent body. It will be headed by a governing board of 6 to 9 people, selected for their ability to take a wide and lateral look at science and technology. They will not be representatives of any particular group.

The role of the new Foundation will be twofold. Firstly, it will have direct access to the Ministry of Research, Science and Technology, providing independent advice on issues such as identifying science priorities. Secondly, the Foundation will allocate a contestabil research fund. From July 1990, 20 per cent of the government's investment in output research, possibly around $50 million, will be used by the Foundation to purchase research. Each year this portion will rise by 10 per cent until in 1993 half of the funding will be allocated by the Foundation. Then there will be a review of Government-funded research.

To begin the new system positively, the Government voted $5 million in new monies to research in the last budget. Under the Priority Research Contracts Scheme, this fund will form the seeding finance of the Foundation. The priorities for this particular scheme are: technologies that will promote the growth of industries, climate change, and antarctic science and logistics.

The government is anxious to maintain a stable scientific career structure, and research funding for longer term projects. This will mean that transitional arrangements will need to be discussed between the Ministry, the Foundation, and the science agencies.

I should note that we cannot in many areas give absolutely clear guideline yet on how things will operate. Certain major policy issues have still to be considered by ministers.

What I can at least give you, is some idea of the timetable in which we would hope to have decisions made and communicated to organisations involved in the contestabil funding system.

I should first note a few principles that the Ministry of Research, Science and Technology will apply in the development of the new funding arrangements.

1. Even at the earliest stage of the development of the new funding processes, it is essential that the government has the flexibility to move towards changes in funding in the light of its priorities.
2. The funding processes should allow for this strategic priority setting without placing an intolerable administrative burden on science managers. The Ministry does not want to jeopardise viable and well-performing research organisations.
3. The processes should be fair to all agencies and should allow resources to flow to those best able to deliver.
4. The funding processes must fit with the requirements of government's financial management reform and the overall budget cycle.

The overall budget cycle framework is shown in Table 1.

Table 1: The Government budget cycle in outline.

Minister/Chief Executive Consultation
Strategic Planning by Departments
3-Year Forecasts
↓
Cabinet Discussion
Government Statement of Priorities of Outcomes
↓
Departmental Draft Corporate Plan
↓
Budget
↓
Corporate Plan Published
Chief Executive's Performance Agreement
↓
Annual Report

In the context of the budget cycle framework, in future years we would see the research funding system operating as shown in Table 2.

This will not be fully implemented for 1990-91 funding. In particular, it will not be possible to carry out national priorities and review processes prior to any decisions on government priorities for outcomes.

Considering departmental funding in particular, departments will be expected to provide the Ministry with statements on proposed programmes for comment. I would expect these statements to include the total cost, the overall goals and short-term objectives, and the justification for funding.

Ministry comment would be based on criteria such as relevance of the programme to government outcomes, technical feasibility, scientific merit, urgency, benefits, and previous record of performance.

Ministry comment would be considered by the Cabinet *Ad Hoc* Committee prior to decisions by cabinet on funding to outputs, and to particular departments within the outputs.

Table 2: Funding system for departmental research.

National Priorities Process	Audit and Review Process
Ad Hoc Cabinet Committee Consultation	October
↓	
Ad Hoc Cabinet Committee Recommendations to Cabinet (Priorities for Outputs and Outcomes)	November
↓	
Government Statement on Priorities	December
↓	
Departmental Information on Proposed Programmes to the Minister of R, S & T	March
↓	
Analysis of Programme Information by MORST	April
↓	
Output Funding Agreed on an Agency by Agency basis	May/June
↓	
Departments Publish Corporate Plans	July

For 1990-91 funding, it is not expected that the government would be making major changes in funding allocation. The Ministry would not have had the opportunity to carry out national priority setting and review processes. However, the Ministry would certainly be commenting on any apparent areas of overlap of duplication of activity.

The new process will place additional performance pressure on the science providers. The Ministry, Foundation and science agencies will accordingly need to work together to ensure that changes in funding priorities are carefully planned, and not unnecessarily disruptive.

Science agencies have shown their ability over the last few years in adapting to change, in moving to user pays and in adapting to the new requirements for financial management and accountability.

In conclusion, the purpose of government's reforms is of course science and technology to the benefit of the community. The Ministry will be focussing its attention not only on government departments but on research activities in the Universities and in industry. It will be important to ensure a productive interaction between agencies, and to ensure that the business climate is receptive to the benefits of technical innovation. The Ministry will be looking at initiatives which will encourage the public and private sectors to work together towards technological change.

It is important that New Zealand remains aware of international developments and plays an active role in the international science and research community. This assists access to the results of research undertaken in other countries, and provides an opportunity for cooperative programmes and for training of New Zealand scientists. The Ministry has the function of maintaining New Zealand's government to government science agreements, and will therefore become an important point of contact for international science activities.

LENTIL PRODUCTION IN CANTERBURY

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ABSTRACT

Lentils have provided Canterbury cropping farmers with a profitable alternative. Average farm yields are high at about 2 t/ha in most seasons. In most seasons the factor most limiting yield is the weather. In wetter than average seasons yields tend to be low due to crop lodging and disease. In dry seasons crops tend to be higher yielding. Sowing date has a significant effect on crop yield with autumn sowings having a higher yield potential than spring sowings due to increased radiation interception. Weed control is crucial to produce a high yielding lentil crop. Increased plant population can help control weeds, however, chemical control and paddock selection are important. Fungal disease can also reduce lentil yields. Since the crop is susceptible to most pea diseases rotations must be lengthy and control measures should be followed.

Additional Key Words: Lens culinaris, esculenta, *dahl, dal.*

INTRODUCTION

Lentils (*Lens culinaris* Medik.) are a relatively new crop to New Zealand. As recently as 1980 there were only very small areas of lentils grown in Canterbury (Jermyn *et al.*, 1981). However, the area sown to lentils has increased significantly with approximately 4,500 ha sown in 1987/88 and about 3000 ha in 1988/89.

Worldwide lentil production is approximately 2.6 million t (FAO, 1987). The most substantial exporters are Turkey, Canada and the USA with total production levels of about 950,000, 328,000 and 81,000 t/annum respectively.

The potential for growth in lentil production in Canterbury is high and may be comparable to that of Canada where in 1979-81 only 38,000 ha of lentils were grown. By 1987, this had increased to 247,000 ha (FAO, 1987).

The crop seems very well suited to New Zealand conditions. At Lincoln College, over a number of seasons, average yields have been about 2,500 kg/ha (McKenzie, 1987) ranging from 700 kg/ha to 3,300 kg/ha. Farmer yields have in some seasons been as high as 4,000 kg/ha. While there are few statistics available on lentil production in New Zealand average farm yields are about 2,000 kg/ha.

While large increases in the area sown to lentils will depend upon obtaining new markets, demand for the product is likely to grow. There is increased interest in reducing fat and cholesterol intake, in human diet, particularly in western countries. Lentils can form a significant component of the daily diet and their amino acid composition complements that of cereals (Savage, 1988). Additionally increasing the lentil proportion of the diet may allow a higher carbohydrate intake while excluding fat. This can help lower fasting serum cholesterol concentrations (Jenkins *et al.* 1980).

HUSBANDRY

In most seasons, lentils are not difficult to grow. Perhaps the most important aspect is to choose a free-draining soil type. The crop is very susceptible to waterlogging.

Cultivar choice is also important. The most common cultivars grown in Canterbury are: Titore, a small seeded red lentil, and Invincible, Olympic and Eldorado, all large seeded yellow cultivars (Jermyn, 1987).

Recommendations for growing a high yielding lentil crop are given in Table 1.

Table 1. Recommendations for growing a high yielding lentil crop.

	Spring sowing	Autumn Sowing
Sowing date	May 15-June 15	Sow 5 September or as early as possible
Seedbed	fine and firm if weeds present spray with Roundup	fine and firm if weeds present spray with Roundup or Paraquat.
Herbicide	cyanazine pre-emergent	cyanazine pre-emergent
Sowing rate	50-70 kg/ha - Titore 70-100 kg/ha - Yellow varieties.	70-100 kg/ha - Titore 100-150 kg/ha - Yellow varieties
Sow	treated seed; use Tecto, Apron or Benlate and Captan sow 2-3 cm deep in 15 cm rows.	
Roll	with a heavy roller after emergence, before plants reach 7 cm in height.	
Irrigation	is not recommended and should only be used in very dry years or on crops sown on very shallow soils.	

FACTORS AFFECTING CROP YIELD

In Canterbury the most significant factor affecting lentil yield is the weather. In wet seasons average farm yields may be as low as 1,000 kg/ha. This is primarily due to disease. However, in wet seasons, excessive vegetative growth is common and crops may lodge. This can be a significant problem with the large seeded yellow varieties. The problem is not usually found in spring sowings.

Generally dry seasons provide the highest lentil yields. However, the 1988/89 growing season was one of the driest on record. Lentil yields were very low that year and there were many crop failures. These failures were probably due to both a lack of available soil moisture and a failure of most herbicides due to insufficient soil moisture to activate the herbicide.

While farmers cannot control the weather, there are a number of factors the farmer can control to increase crop yield. These factors include: sowing date, weed control, choice of cultivar and disease control.

SOWING DATE

Work at Lincoln University has consistently shown that autumn lentil sowings out-yield spring sowings. Results from an experiment in 1984/85 showed that all autumn/winter sowings produced at least 2,000 kg seed/ha while all spring/summer sowings produced less than 1,500 kg seed/ha (Figure 1). Autumn sowings have a higher yield potential than spring sowings because they intercept more solar radiation (McKenzie, 1987).

Autumn sown lentil crops close their canopies earlier and have a longer crop duration than spring sown crops.

Yields of spring sown crops can be increased by increasing the seeding rate (McKenzie, *et al.*, 1989). This results in increased radiation interception and reduced weed competition.

WEED CONTROL

Effective weed control is essential for a high yielding lentil crop. Lentils are not a competitive crop and should not be grown in weedy paddocks. The

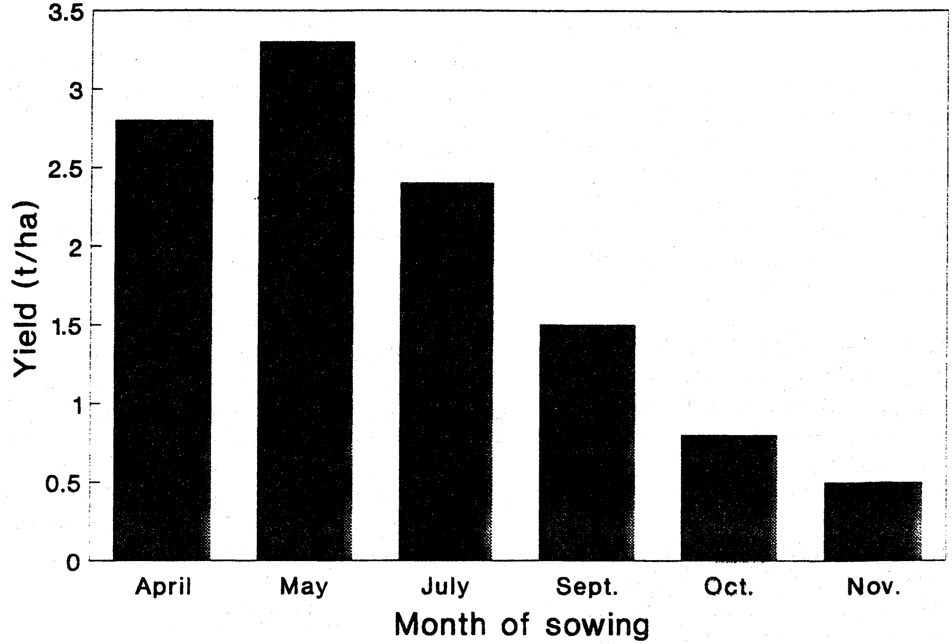

Figure 1. **The effect of sowing date on seed yield of lentils**

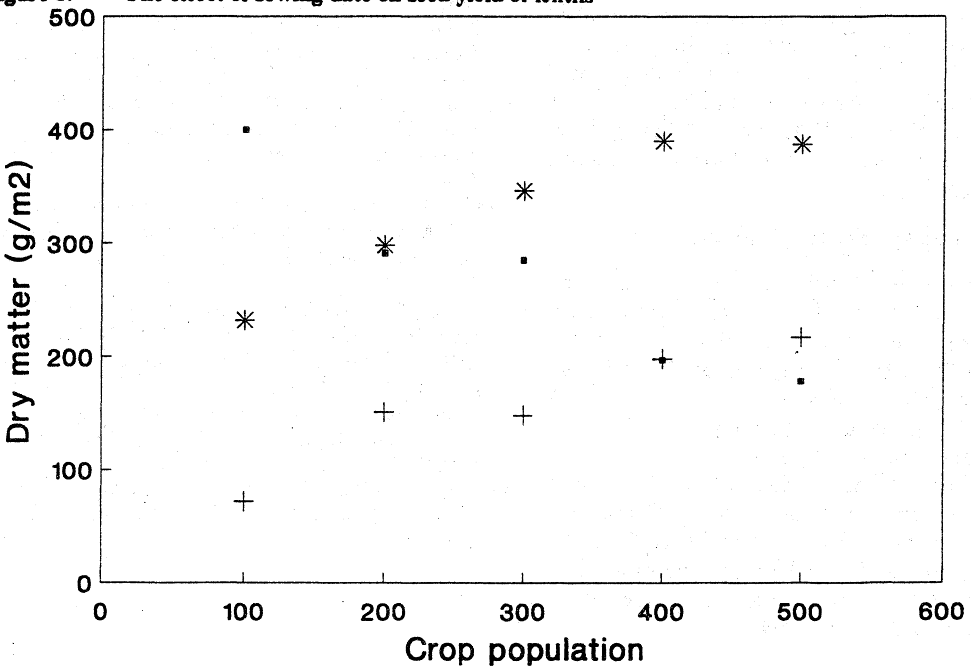

Figure 2. **The relationship between crop population (plants/m²) and dry matter production of weeds (.), lentils (+), and weed free lentils (*).**

effect of weed and lentil population on lentil yield is shown in Figure 2.

While high lentil populations can reduce weed competition and increase yields, these high populations would also cause high establishment costs. In most paddocks, cyanazine will give good weed control when applied pre-emergent. Post-emergence the only chemical which seems to be effective is metribuzin. Care must be taken with this herbicide however as crop damage may occur.

CULTIVAR SELECTION

This factor can have an important bearing on yield. In work at Lincoln, the small red lentil Titore has been shown to consistently yield more than any of the yellow varieties (McKenzie, 1987). This variety is a DSIR selection and is well suited to the Canterbury environment.

Among the yellow varieties Olympic has proven to be nearly as high yielding as Titore. It is also quite flexible and can be sown in autumn or spring. If spring sowing is necessary, Invincible is a suitable cultivar.

Trials with a new extra large seeded variety called Primera have proven disappointing with yields only about half of those of Titore. In areas of high rainfall or on moderately heavy soils, the yellow cultivars may be prone to lodging and excessive vegetative growth. Both of these characteristics tend to reduce harvest index and seed quality.

DISEASE CONTROL

Lentils are susceptible to many of the same diseases which affect peas. Perhaps the most important of these is *Ascochyta fabae* f. sp. *lentis* (Jermyn, 1987). After the crop canopy closes disease spread can be rapid in damp weather. The very dense canopy inhibits penetration of sprays. This means the crop must be monitored frequently.

There are a number of other diseases which also affect lentils. These include: *Botrytis, Sclerotinia sclerotiorum, Pythium* and *Rhizoctonia*. Additionally *Aphanomyces euteiches* can be a problem and paddocks with an Aphanomyces index over 50 by MAF soil test should be avoided.

IRRIGATION

Irrigation of lentils has been intensively studied at Lincoln University. With field grown lentils, there seems to be little response to irrigation even in dry seasons. On any soil type other than shallow stony soils irrigation is unlikely to give high seed yields except in the driest of years.

Irrigation tends to increase vegetative growth often with increased plant lodging and disease.

CONCLUSIONS

Lentils clearly have a bright future in the cropping scene in Canterbury. They seem to be an ideal crop for the region particularly as irrigation water is likely to become less available and more expensive. There are no serious reasons why lentil production should not continue to expand rapidly in Canterbury. However, the rate of growth and the success of the crop will depend upon developing suitable markets.

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THE POTENTIAL OF PEANUTS AS A CROP IN NEW ZEALAND

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ABSTRACT

New Zealand currently imports peanuts and peanut products to a value of $5 million per annum. Agronomic trials in the north of the country have indicated that good yields of this crop can be obtained. Recommendations are given for the cultivation of peanuts and an estimated gross margin is given.

INTRODUCTION

New Zealand imports approximately 4 - 6,000 t of peanuts and peanut products worth approximately $5 million out of total annual imports of vegetable oils of approximately $38 million (Table 1).

Over the last ten years many groups and individuals have expressed interest in attempting to grow peanuts in different parts of New Zealand.

Peanuts have been successfully grown on a small scale in New Zealand for many years. The first peanut research trials were carried out over twenty years ago, indicating that only the more northern areas of New Zealand would be suitable for commercial production.

Further peanut trials started in 1978 when 73 lines were evaluated at Pukekohe. In the following two seasons the better performing lines were evaluated at Pukekohe, Helensville, Dargaville and TeHapua. Yields were variable but in the better trials mean trial yields exceeded 2 t/ha with the better lines yielding up to 3 t/ha (Anderson & Piggot, 1981) The better lines were all Spanish or Valencia types peanuts, the later maturing Virginia types being low yielding in all trials in which they were grown.

CROP PRODUCTION

The most recent cultivar evaluation at different sites was carried out in 1985/6 and results are shown in Table 2.

At Gisborne the site was very dry and peanuts were sown in wide 75 cm rows. It is believed that the yield could have been higher if row spacing had been 50 cm as in the other trials. Over all trials the cultivar New Mexico has given the most consistent performance and since 1986 has been the only line distributed to people wanting to grown peanuts in New Zealand.

Many successful small scale blocks of up to 0.2 ha of peanuts have been grown in different areas of New Zealand including Northland, Auckland, Bay of Plenty, Poverty Bay, Hawkes Bay and Marlborough. The best recorded yields of shelled peanuts have exceeded 4 t/ha at Helensville and Kerikeri but there have also been several plantings with very low yields. Where crops have been unsuccessful the most common reason for failure has been poor weed control. However effective herbicides are available for peanuts and weed control need not be a factor limiting the viability of the crop.

Diseases have not been a major problem except where seed was not treated with a fungicide prior to sowing or in very weedy crops where *Sclerotinia* has sometimes been a problem.

The only major insect problem encountered so far has been onion fly maggot reducing plant emergence on land straight out of pasture.

RECOMMENDATIONS FOR GROWING PEANUTS

Some recommendations for growing peanuts have been drawn up as a result of experience in running these trials and these are listed below.

Seedbed preparation: Normal seedbed preparation as for cereal or pasture crops but care should be taken to ensure that there is no history of serious weeds such as *Amaranthus* sp (red shank), *Chenopodium album* (fat hen), or *Solanum nigrum* (black nightshade).

Sowing time: Recommend that sowing is delayed until soil temperatures have risen above 15 °C. In areas where peanuts are likely to be grown this is likely to be between mid-October and early November.

Table 1: **New Zealand imports of peanuts and peanut products 1987-88.**

	Quantity (kg)	$ Value
Roasted peanuts	174,200[1]	293,800
Uncooked peanuts	3,533,300[2]	4,556,200[3]
Peanut Butter	141,400	487,300
Peanut Oil	334,600	471,000
Total	4,183 t	$5,798,300

[1] 80% of cooked peanuts are imported from Australia. [2] Major suppliers of uncooked nuts include USA 40% (at an average landed price of $NZ1,160/t), China 26% and Australia 23%. [3] Average landed price of uncooked peanuts 1987-88, $NZ1,289/t.

Table 2: **1985-86 peanut trial results**

	Shelled Peanut Yield t/ha.			
Cultivar	Helensville	Pukekohe	Gisborne	Cultivar mean
OAC 6-78-4	2.41	2.91	1.69	2.34
New Mexico	2.42	2.86	1.65	2.31
OAC 37-24	2.58	2.54	1.66	2.26
Valencia Senegal	2.50	2.57	1.64	2.24
Garroy	2.77	2.33	1.40	2.17
CPI 46724	2.48	2.40	1.24	2.04
OAC 17-78-2	2.29	1.85	1.79	1.98
CPI 42442	2.67	1.78	1.45	1.97
OAC 12-78-12	2.54	2.54	1.84	1.49
OAC 29-78-7	2.23	2.14	1.39	1.92
OAC 21-78-7	1.95	1.85	1.72	1.84
Site Mean Yield	2.44	2.28	1.56	
CV	Site	10.9	Cultivar	17.1
LSD ($P < 0.05$)		0.36		0.29
Overall Mean Yield				2.09 t/ha

Fertilizer: A major requirement is a soil pH of 5.8 and high in available calcium. Otherwise fertilizer requirements are moderate. Peanuts are good nodulators so no nitrogen is required if inoculated.

Insect control: Onion fly and maggot as well as pasture pests such as grass grub and soldier fly have been a problem however all can be controlled by Diazinon.

Diseases: There are no major diseases requiring regular fungicide treatment.

Weed control: A Lasso/Linuron pre-emergence spray is usually adequate for weed control, however if some weeds, especially grasses, persist a second herbicide may be necessary.

Table 3: Estimated gross margin for growing peanuts.

		hr/ha	$/ha	Sub-total	Total
Gross revenue for a crop yield of 2.4 t/ha at a price of $650/t					$1,560
Variable costs					
Cultivation					
Chip hoe		0.6			
Plough		1.4			
Hoe		0.6			
Harrow, roll		0.3			
Drill		0.8			
Total hours		3.7	$10,00	$37	
Seed	50	$1,100/t		$55	
Fertilizer					
Pottasic Super (kg/ha)		100	$390.00/t	$39	
Herbicide					
Treflan (kg/ha)	2		$9.45/kg	$19	
Post emergence	1		$40.00/kg	$40	
Application		1.6	$8.39	$13	
Insceticide					
Diazinon (kg/ha)	0.25	$40.00/kg	$10		
Application		0.8	$8.39	$7	
Harvesting					
Lifting and heading	12.00	$17.79	$213		
Drying			$40.00/t	$96	
Cartage	2		$20.00/t	$40	
Total Costs				$569	
Total revenue					$991

The gross margin for a 2.4 t/ha crop of peanuts is shown in Table 3, and a sensitivity analysis in Table 4.

THE FUTURE

The major factor limiting the future of peanuts in New Zealand is currently harvesting equipment. A number of growers have grown peanuts successfully in small areas and then expanded in area beyond what they could harvest by hand in the limited time available. They lost a considerable proportion of their production, as well as their enthusiasm for growing the crop. Commercial scale shellers will also be needed before large areas are grown. DSIR Crop Research has a small sheller which has been made available to several growers.

Commercial driers may also need modification to handle peanuts as peanuts cannot be augered. In the current season (1989-90) the largest individual crop being grown in New Zealand was 1 ha in the Bay of Plenty crops exceeding 0.2 ha were also grown in Northland and Hawkes Bay. Development of a locally built harvester is also being undertaken. If this is completed satisfactorily the development of peanuts as a commercial crop may be possible.

In Southern Ontario small groups of growers share machinery in a cooperative and a similar organisation could perhaps work in New Zealand. In Ontario trials on peanuts commenced around 1970, and growers started commercial production around 1980. Production fluctuated around low areas for several years but in 1988 the area of peanuts rose to 350 ha and looks set to expand into a significant crop for the region.

New Zealand has the potential to grow the majority of the peanuts consumed here. There are a number of areas with a sufficiently warm season and with suitable friable and free draining soils that can successfully grow

Table 4: **Gross margin sensitivity analysis for yields from 1.5 to 3.5 t/ha and prices from $600 to $1,000/t.**

Price	Yield (t/ha)				
	3.5	3.0	2.5	2.0	1.5
$	$	$	$	$	$
600	1,531	1,231	931	631	331
644	1,685	1,363	1,041	719	397
689	1,842	1,498	1,153	809	464
733	1,996	1,630	1,263	897	530
777	2,150	1,762	1,373	985	596
822	2,308	1,897	1,486	1,075	664
866	2,462	2,029	1,596	1,163	730
911	2,619	2,164	1,708	1,253	797
956	2,777	2,299	1,821	1,343	865
1,000	2,931	2,431	1,931	1,431	931

Spanish and Valencia type peanuts. There is interest from growers and provided investment is made in harvesters, shellers, and driers there is a good chance of this potential being realized. Commercial shellers would be easy to obtain from Australia.

New Zealand growers would be in a better position than peanut growers in other countries to grow the crop organically. Pests and diseases which are potentially devastating in other countries, are either not present here or are unlikely to be problems. For example fungal problems such as *Cercospora* which require regular spraying in Australia is not a problem as temperatures are below epidemic threshold levels.

CONCLUSION

There are no technical difficulties to growing peanuts in New Zealand, in fact there appear to be many advantages.

Success or failure will depend upon returns to growers and competing opportunities for growers.

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CHICKPEAS

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ABSTRACT

Chickpea (*Cicer arietinum*) is a crop with potential for local consumption and export both as a human food and animal feed. Chickpea also is a good supplier of nitrogen to following crops. Australia has taken up this challenge and has developed an industry along all five lines given above, producing information and varieties of interest in New Zealand. Local fine tuning of the agronomic package and selection of varieties that encompass agronomic (frost tolerance) and market advantages (e.g. large seed size) is needed and is taking place in a relatively small way at present. The crop has good prospects for expanded production in New Zealand.

Additional Key Words: Bengal gram, Desi, Garbanzo, Kabuli.

INTRODUCTION

Chickpeas are a crop showing great potential for production in New Zealand. Seventy tonnes of the large seeded (Kabuli) types are imported annually into New Zealand for human consumption (Deptartment. of Statistics, 1989). There are also substantial potential export markets available as indicated by the expansion of production in Australia. These markets are for both the large and small (desi) seeded types for both human consumption and potentially for animal feed production.

Quality is an important factor in production for local human consumption. For instance, Macareena chickpeas grown in the Ord Irrigation Aarea, have captured about 50 % of the local Australian market due to their very large seed size (600 mg - 640 mg/seed) compared to Opal (400 - 500 mg/seed). With different lines showing variations in anti-nutritional factors and digestible energy content, choice of appropriate varieties is also important in the animal feed industry. Little research has been carried out in New Zealand. Some agronomic work has been conducted at Lincoln University (Hernandez, 1986) and some variety work is being conducted by the Crop Research Division of the DSIR at Lincoln (W. Jermyn, personal communication).

NEW ZEALAND RESEARCH

Suitability of the crop for production in New Zealand has been assessed by Logan (1983), Farnsworth (1985) and Hernandez (1986). Breeding research and cultivar evaluation is continuing at Crop Research Division, DSIR, Lincoln (Jermyn, pers. com.). A major objective is to obtain frost tolerant and disease tolerant, high yielding large seeded kabuli types. Hernandez & Hill (1983, 1984, 1985) showed that 33 plants/m^2 were adequate for maximum yields in both desi and kabuli type chickpeas under Canterbury conditions (2.1 - 2.7 t/ha) with a 29 % increase in yield resulting from inoculation. Work elsewhere has suggested for kabuli types even lower populations at 12 - 14 plants/m^2 are adequate for maximum economic yield (McNeil, 1988).

Ascochyta blight was a major problem with the crop particularly during the cool wet 1984 season.

September sowing proved to be optimal, achieving maximum light absorption and maximum yield (Hernandez & Hill, 1985). However, this may not always be the case as low soil temperature may inhibit and slow germination leading to poor establishment. This is a consistent problem in chickpeas, particularly the large seeded types.

AUSTRALIAN RESEARCH

Weed control: Slow early crop growth can create major problems in weed control of chickpea crops. Broadleaf weeds are the most serious problem and several strategies have been developed for their control.

Good broadleaf control in a preceding cereal crop has been found to help and in some regions (McNeil & Heap, 1986) a mixture of Trifluralin plus interrow cultivation has given good weed control in conjunction with a paraquat plus diquat spray between sowing and emergence.

Post-emergent fluazifop for grass weed control is registered for use in Queensland.

Experimental work in Victoria has suggested Bladex at 3 l/ha gives good broadleaf weed control and yield increases. Sencor T and Igran were somewhat less effective (Mahoney, 1984). None of these chemicals can however be recommended as yet in New Zealand.

Plant nutrition: Chickpeas have been shown to respond to S, P, Zn and Fe though they are less responsive than other legume crops (Saxena, 1980, Reuter, 1986).

There are some indications that late applications of N benefits vegetative growth but not yield (Hernandez & Hill, 1984; Riley *et al.*, 1987).

Chickpeas are efficient nitrogen fixers of and have given carry-over residual effects in New South Wales and Queensland equivalent to 50 to 100 kg of N/ha (Strong *et al.*, 1986; Armstrong, 1987).

Time of planting: Experiments in Victoria and New South Wales have indicated that autumn and winter sowing of chickpeas gave maximum yields in those environments (Pye, 1989 unpublished) provided frost tolerant genotypes were available.

Water use: Chickpeas, like many other legumes, are extremely sensitive to waterlogging and poor soil structure. Experiments have demonstrated substantial benefits from deep ripping and improved yields with reduced irrigation frequencies where soil roots could obtain greater volumes of water from depth (Riley *et al.*, 1987).

Chickpeas are capable of excellent growth with little water, however, well watered crops give optimal yields (McNeil *et al.*, 1986) provided leaf and root diseases are controlled.

Diseases: Elsewhere chickpeas are subject to a broad range of leaf and root diseases. Major leaf diseases in Australia are Botrytis grey mould (*Botrytis cinerea* Pers. ex. Fr). Sclerotinia stem rot (*Sclerotinia sclerotiorum* (Lib.) de Bary, *S. trifoliorum* Erikss.), Ascochyta blight (*Ascochyta rabiei* (Pass.) Labr.). Phoma blight (*Phoma medicaginis* Malbr. and Roum.) and bacterial blight (*Pseudomonas andropogonis* (Smith) Stapp.). Most of these diseases can be controlled by use of disease free fungicide treated seed and crop rotations. Wider row spacings to produce less humidity in the crop may also help (Bretag & Mebalds, 1987; Haware *et al.* 1986; Jiminez-Diaz & Trapero-Casas, 1985).

The major chickpea root disease in Australia, Phytophthora root rot, *Phytophthora megasperma* (Drechs) f. sp. medicaginis, Kuan & Erwin is only important in Northern Australia. Seed dressing, use of phosphoric acid sprays and host resistance can all be used in its control (Ryley & Irwin, pers. com. 1988) To date the other major root disease of chickpeas *Fusarium oxysporum* f. sp. *Ciceris* has not been recorded in Australia or New Zealand. A broad complex of other rots e.g. *Rhizoctonia, Botrytis, Pythium, Fusarium, Sclerotinia* can cause seedling and adult plant deaths. Most of these can be controlled by seed dressing.

Viruses cause severe losses in some regions in some years. However, at present they do not appear to be a major problem (M. Schwinghamer, pers. com. 1988).

Insects: Chickpeas usually have a coating of oxalic acid on their leaves which discourages many insect pests. However, this can lead to uncontrolled population explosions of resistant pests as natural predators are not present. This appears to be the case in Australia with *Heliothus* sp. which is a major problem (McNeil & Heap, 1986). Soil insects may also be a problem and can cause seed and seedling losses, by damage and infection by fungi (Riley *et al.*, 1987).

There is a large literature which covers chemical, virus, pheromone and integrated control strategies for Heliothus.

Root nematodes have also been implicated in yield losses of chickpea particularly the root lesion nematode *Pratylenchus thornei* (Walia & Seshadri, 1985 a, b).

Quality: Most chickpeas are semi-prostrate in habit requiring harvest close to the ground or windrowing prior to harvest. As soil and split seed tolerances may be low for export markets (e.g. none and 2 % for the Spanish market) and seed discolouration can also be a problem in kabuli types, care must be taken throughout the production and marketing chain to reduce these problems.

Genetic Resources: Major world germplasm collections for chickpeas are held at ICRISAT (India), USDA (USA), ICARDA (Syria), and ATFCC (Australia). A major breeding programme in Australia exists at Tamworth, in New South Wales. The Crop Research Division of the DSIR is involved in evaluation of genotypes. Lincoln University also has an interest in evaluation of autumn sown *Kabuli* types in collaboration with ICARDA.

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NAVY BEAN PRODUCTION IN CANTERBURY

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ABSTRACT

Navy beans have been shown to consistently produce up to 3 t/ha of dry seed in Canterbury. Experimental work has shown that to ensure high yields irrigation is essential. In a dry season irrigation can increase yield by up to 250 %. Crop husbandry is relatively simple. However, the mid to late November sowing date means the crop is exposed to the danger of both late and early frosts. The crop can provide a profitable alternative to Canterbury cropping farmers, however, it is only recommended to those with specialist cropping experience.

***Additional Key Words:** french bean, kidney bean,* Phaseolus vulgaris.

INTRODUCTION

Until recently New Zealand has consistently imported significant quantities of navy beans (***Phaseolus vulgaris*** L.) primarily for use in tinned baked beans. However, the area sown to navy beans has been increasing rapidly and presently approximately 800 - 1000 ha are being grown each year.

While environmental conditions in Canterbury are somewhat marginal for navy beans the crop has consistently yielded well in experimental work at Lincoln College. With irrigation seed yields are usually near 3 t/ha from small plots (Love *et al.*, 1988).

In 1974, Goulden reported yields ranging from 1.4 to 3.3 t/ha in Canterbury.

However, the crop can be risky for growers with variable yields particularly in dryland conditions. The crop is of short duration, and has to be sown in late spring due to it's frost sensitivity.

The Canterbury growing season is characterized by hot dry North West winds, which cause high soil moisture deficits. The combination of low night temperatures and dry conditions can result in low yields in the absence of irrigation.

An additional problem with the crop in Canterbury is the delay in maturity which can occur in wet seasons or with late sowing. This can cause harvesting problems or seed quality problems due to fungal infection of pods.

While there are some problems for growers, the crop can be profitable and can provide growers with a valuable addition in their crop rotation.

HUSBANDRY

The crop should be sown in mid to late November on a fertile free draining site. The crop is usually sown in 15 cm rows 4 to 5 cm deep. A suitable plant population is about 60 plants/m^2.

Since the plants are not aggressive, weed competition should be minimized with trifluralin.

Navy beans are not efficient at fixing atmospheric nitrogen due to poor symbiosis and a low genetic ability (Graham, 1981). For this reason nitrogen is usually applied to the crop. Overseas recommendations usually suggest nitrogen application at sowing. In New Zealand however, temperatures in mid-November can drop below 11° C. At these low temperatures nitrogen application can result in severe plant damage (Andrews *et al.*, 1989). Because of this nitrogen application should be delayed until mid-December.

Finally, dryland navy bean crops are very risky. The crop can only be recommended for growers with irrigation.

IRRIGATION

The most important factor which affects seed yield is irrigation. At Lincoln College, with irrigation, seed yields have consistently been around 3 t/ha. Even in wet seasons, such as 1983/84, irrigation has given significant yield increases (Table 1).

Table 1: The effect of irrigation on navy bean seed yield at Lincoln College in 1983/84 and 1984/85 (Love *et al.*, 1988).

Irrigation	Seed Yield (g/m²) 1983/84	1984/85
Full	319	309
Nil	278	131
Significance	**	***
SE	3.2	10.9

, * significant at $P < 0.01$ and 0.001 respectively.

In most seasons, in Canterbury a very high potential soil moisture deficit builds up in February and March. Without irrigation this deficit will significantly reduce seed yields.

POPULATION

Like most other grain legumes, navy beans exhibit plastic responses to plant population. At high populations, there will be only a small number of pods/plant while at low populations there will be a much larger number. However, overall yield is much less sensitive to population and the effect may depend on other factors such as soil moisture content (Table 2).

While population may have only a small effect on seed yield, it can increase plant height and lift the pods farther from the ground (Love *et al.*, 1988). this can produce plants which are easier to harvest and less prone to fungal infection on the pods (Table 3).

SHELTER

In Canterbury strong North West winds have been shown to cause significant crop damage (Sturrock, 1969). In trials at Lincoln College, shelter has only provided small uneconomical increases in seed yield. The most significant yield increase with shelter was only 5.8 %.

Table 2: The effect of plant population on seed yield of navy beans in two seasons in Canterbury.

Population (Plants/m²)	1983/84 irrigated + unirrigated	
44	292	
94	305	
Significance	*	
SE	4.2	
	1984/85	
	irrigated	unirrigated
30	291	135
50	313	134
70	325	125
SE	10.9	3.1

* significant at $P < 0.05$.

Table 3: The effect of plant population on the height of the lowest point of the pod above the ground (Love *et al.* 1988).

Population (plants/m²)	Height (cm)
30	3.7
50	5.1
70	7.4
Significance	**
SE	0.4

** significant at $P < 0.01$.

CONCLUSIONS

Navy beans can be grown successfully in Canterbury. However, the crop requires proper husbandry and is only suitable for specialist growers. Without irrigation the crop is unlikely to be viable and in wet seasons there may be significant problems with harvesting due to delayed maturity.

Although there are problems, at the present high prices for navy beans, the crop is attractive to growers.

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LUPINS

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ABSTRACT

There are currently two species of lupins, *Lupinus angustifolius* and *L. albus*, which have potential as grain legume crops for the New Zealand environment. *Lupinus angustifolius* was grown in Canterbury before and immediately after the second war as a fertility- restoring crop and as a source of high quality feed for sheep. New Zealand experiments conducted in the early seventies with the then new, West Australian, sweet, non-shattering genotypes of this species gave experimental seed yields in Canterbury of 7 t/ha. New Zealand farm yields were up to 5 t/ha. Experiments also confirmed the ability of this species to fix large quantities of atmospheric nitrogen. When a standing lupin crop was grazed by sheep, up to 80 kg/ha of nitrogen was returned to the soil for succeeding crops.

Yields of *L. albus* have not been as high, but this species is of interest to animal nutritionists - because of its high seed protein and oil concentration - for the formulation of rations for monogastric animals. Maximum reported seed yield in New Zealand is 4.0 t/ha.

In the longer term the South American species *L. mutabilis* may have potential in New Zealand as both an oil and protein crop.

***Additional Key Words:** Agronomy, pests and diseases,*Phomposis leptostromiformis.

INTRODUCTION

It is ironical that the lupin species *L. angustifolius*, which is the basis of the large West Australian lupin seed industry, was for many years known in that state as the New Zealand blue lupin. Claridge (1972) records that in the late 1940s more than 4,000 ha of *L. angustifolius* were grown for seed in Canterbury. The plant was used for the feeding of lambs and ewes and to restore fertility. Over the years the interest in lupins for seed has waned and they now no longer feature in the agricultural statistics. During this time, mainly as a result of the efforts of J.S. Gladstones (a West Australian plant breeder), a new range of *L. angustifolius* genotypes was being produced without many of the poor agronomic features that dogged the pre-war genotypes and made them so unreliable to grow. Gladstones combined the alkaloid-free gene discovered by von Sengbusch in the 1920s with genes for non-shattering and for the removal of a vernalization requirement (Gladstones, 1970). These new lines became the foundation of the Australian lupin seed industry. The estimated area sown to lupins in 1989 - 90 in Australia is 898,000 ha in Australia (ABA & RE, 1989a) where it still has a major role in its traditional uses as a supplementary feed for sheep (Hill, 1988) and in soil fertility restoration (Rowland *et al.*, 1986). However, sweet *L. angustifolius* seed is extensively used in Australia for the production of pig and poultry rations and pet food (Hill, 1977, 1986). Its popularity in this role arises from its high seed protein concentration and lack of toxic factors common in other grain legumes. At the same time lupin seed is being exported from Australia, mainly to Asia. The gross value of the Australain lupin crop for 1989 - 90 is estimated at $A179 million and the 445,000 t which were exported earned Australian Farmers $A101 million (ABA & RE, 1989b).

Potential *L. angustifolius* yields are considerably better in New Zealand than in Australia and the early Australian cultivars appeared to be well adapted to the New Zealand environment (Herbert & Hill, 1978a; Herbert,1978). Seed yield potential of *L. albus* in New Zealand is greater than 4 t/ha (Herbert, 1977a; Kelly, pers comm.). *Lupinus albus* seed has both higher seed protein and oil concentrations than *L. angustifolius* (Hill, 1977). However, despite their agronomic potential neither species has gained widespread acceptance in New Zealand agriculture. This paper briefly reviews agronomic knowledge of these two lupin species in the New Zealand environment and closes with a brief discussion of the potential of the South American highland species *L. mutabilis* in the New Zealand environment.

AGRONOMY

Sowing date: Unlike a number of other grain legumes such as faba beans and lentils there appears to be little advantage in autumn-sowing lupins in New Zealand. Experiments with *L. albus* and *L. angustifolius* conducted at Lincoln, which involved a series of sowings from April to November, showed little difference in seed yield among the various sowing dates before the November sowing (Horn & Hill, unpublished data). The high yields obtained by Herbert & Hill (1978a) from *L. angustifolius* were from an early October sowing, and *L. albus* yielded well when sown in late September (Herbert, 1977a). The higher yields from spring sowings might be the result of reduced plant population of autumn sowings in the spring, following selective grazing during winter of young sweet lupin plants by hares.

Plant population: Herbert & Hill (1978a) investigated the effect of plant population on irrigated and unirrigated *L. angustifolius* at populations from 27 to 156 plants/m^2. There was no yield response in unirrigated plants but with irrigation there was a linear increase in yield as population fell. Hill *et al.* (1978) found no difference in lupin seed yield when lupins were sown in rows 20 cm apart and 40 cm. Similar results were obtained by Herbert & Hill (1978b) with rows 15 cm and 30 cm apart. Although yield fell as population was increased, a population of 70 plants/m^2 in narrow rows was recommended for reasons of improved weed suppression (Herbert *et al.*, 1978) and more uniform crop maturity at the end of the growing season (Herbert, 1977b).

Similarly with *L. albus*, Herbert (1977a) found that seed yield increased from 2.1 to 3.2 t/ha as plant population increased from 16 to 36 plants/m^2.

Seed bed preparation: Lupins are large-seeded and tend to do well in friable soils which are free draining. They do not require fine seedbeds and respond very poorly to soil compaction. Further, there have been no reports in the New Zealand literature of seed lupins responding to phosphate fertilizer on cropping soils and therefore only maintenance levels of superphosphate need to be applied. Although generally there are sufficient rhizobia in New Zealand soils to nodulate lupins without inoculation Rhodes (1976) obtained yield increases of up to 500 kg/ha in response to inoculation.

Herbicides: In early New Zealand work, trifluralin was used for weed control in lupins. Lucas *et al.* (1976) found that atrazine at 1.1 kg a.i./ha maximised seed yield. Similarly, Rhodes (1976) found that as the rate of atrazine increased from 0.2 to 0.8 kg a.i/ha, yield increased significantly. In Australia simazine at 1.5 l/ha, or simazine in conjunction with trifluralin, are recommended for weed control in grassy paddocks (Gilbey, 1986).

Irrigation responses: Stoker (1975) at Winchmore, on a Lismore stony silt loam, increased the mean yield of *L. angustifolius* and *L. luteus* from 1.2 t/ha to 3.5 t/ha with irrigation. However, Herbert (1978) found that on a Wakanui silt loam, in a wet season, crop yield in *L. angustifolius* was reduced by irrigation. In both these trials irrigation water was applied in accordance with the physiological growth stage of the crop rather than on calculated or measured soil moisture deficit. It is therefore possible that significant yield increases to irrigation may be obtainable with lupins if water were applied according to crop demand. More work is required in this area.

Aphids and viral diseases: A major problem with the growing of sweet lupins in Canterbury is the transmission of aphid borne viral diseases particularly bean yellow mosaic virus and the persistent subterranean clover red leaf virus (Teh, 1978). It is therefore important that aphid infestations are controlled during the growth of the crop.

NITROGEN TRANSFER

Total nitrogen fixation: The growing of lupins has traditionally been promoted for the large amount of nitrogen fixed by the crop. Burtt & Hill (1981) measured the equivalent of 330 kg N/ha in a standing lupin crop which had been grown on a soil on which cereals had responded to nitrogen fertilizer in the previous season. In a somewhat less productive crop McKenzie & Hill (1984) found 150 kg N/ha in a standing lupin crop. However, it is not the amount in the standing crop that matters but how much is available for the following crop that is important.

Once lupins are grown they can be either grazed *in situ* or harvested for seed. In the former case most of the nitrogen in the crop is returned to the soil, while in the latter case only the nitrogen in the crop residues is available. McKenzie & Hill (1984) grazed a standing spring sown lupin crop 100 days after sowing and estimated that 80 kg N/ha was returned to the soil. Although initially with autumn sowing Janson & Knight (1980) found little benefit from grazing autumn sown lupins a later experiment using a bitter cultivar of *L. angustifolius* (Janson, 1984) gave a substantial yield increase in spring wheat from 3.2 t/ha to 4.6 t/ha. While in McKenzie & Hill's (1984) trial the yield of Tama ryegrass was increased from 3.4 t/ha following barley to 5.6 t/ha following lupins grazed at 100 days after sowing.

Because a considerable amount of the total nitrogen in the lupin crop is in the seed at harvest most of the above ground nitrogen is removed with the crop. Thus the only nitrogen left is in pods walls and stubbles. For example Burtt & Hill (1981) found that of 33 g/m^2 of nitrogen in the standing crop only 3 g/m^2 was in the stubble at crop maturity. However, in Australia substantial wheat yield increases have regularly been obtained from the growing of wheat after lupins (Rowland *et al.*, 1986). It can be argued that wheat yields in Australia are generally lower than in New Zealand but in Launceston, Tasmania wheat after wheat yielded 3.83 t/ha while wheat after lupins gave 4.46 t/ha. Further, McKenzie & Hill (1984) showed that following the harvest of a lupin crop for seed the yield of the following greenfeed crop was the same as when the land was fallowed. There are three possible explanations for this increase in yield in spite of the apparently low amounts of nitrogen involved. Firstly, by maturity the leaves fall off lupin plants and no measurements have been made of their nitrogen content. Secondly, there is no published information as to either the total underground lupin biomass or its nitrogen concentration at crop maturity and the amounts involved may be quite substantial. Finally, no account is taken of harvesting losses of lupin seed. Australian work has indicated that these can amount to 360 kg/ha (Croker *et al.*, 1979) which would contain about 18 kg/ha of nitrogen. Thus the benefits gained from growing a crop of lupins are greater than the value of the forage or seed produced, and in a cropping situation their use could provide a method of increasing the intensity of the rotation. Apart from the addition of nitrogen a further advantage of lupins is that they are not an alternative host to the pea root disease *Aphanomyces euteiches* (Scott, 1987).

FUTURE POTENTIAL

Based on published agronomic results there is little doubt that good farm yields of both *L. angustifolius* and *L. albus* can be obtained in New Zealand. Since the breeding of Uniwhite, Unicrop and Uniharvest West Australian plant breeders have continued to produce new lupin varieties. Many of these are now resistant to a range of diseases of lupins and in particular a recent releases Gungrurru (Gladstones, 1988) is resistant to the fungus *Phomopsis leptostromiformis* which is the causative agent of the disease lupinosis in sheep. Further work in Western Australia is aimed at producing determinate cultivars. However, the variety Danja which was released in 1986 has improved pod number and harvest index and thus a higher yield. It would therefore be important that if *L. angustifolius* was to be considered again for evaluation in New Zealand that the most recently available varieties are tested.

Similarly with *L. albus* more recent varieties may give higher yields than the cultivars tested in the 1970s. The variety Llaima bred by von Baer in Chile and tested recently in Canterbury gave seed yields of up to 4.0 t/ha (Kelley, pers comm.) compared with a maximum of 3.2 t/ha for variety Hamburg obtained by Herbert (1977).

Finally the South American Andean species *L. mutabilis* which has a seed oil concentration similar to that of soya beans combined with an extremely high seed protein concentration (Hill, 1977, 1986) of high nutritional quality (Savage *et al.*, 1983, 1984) grew well in early New Zealand trials (Hill *et al.*, 1977; Horn *et al.*, 1978). The breeding of the alkaloid free variety Inti of this species by von Baer & von Baer (1986) indicates that it should also be further evaluated in the New Zealand environment.

Agronomically lupins can be grown, it remains to promote their use in local animal feed formulation. Having establish a local market it should be possible for New Zealand to obtain a share of the market for lupin seed that the Australians have developed.

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Vicia faba

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ABSTRACT

The species *Vicia faba* is an ancient crop which is well adapted to cold, wet conditions. It can be grown either for production of frozen broad beans or for dried seed, which is of high nutritional quality. There are considerable differences in the mean seed weight among genotypes of this species and to some extent the end use of the dry seed depends on seed size.

Research work in New Zealand has shown that provided disease free seed is sown, in autumn, at population of about 70 plants/m² and the crop is provided with water, when required, that seed yields of up to 6 t/ha can be obtained. The crop has also been evaluated as a winter greenfeed for ewes and can produce up to 4.3 t/ha of forage by late May when sown in February. A yield increase of 1.8 t/ha was obtained from a succeeding spring wheat crop.

Additional Key Words: Aphis craccivora, Ascochyta fabae, Botrytis cinerea, Uromyces vicae-faba, ***harvest index, nitrogen, pests and diseases.***

INTRODUCTION

Vicia faba is an ancient crop of Mediterranean origin. Its dried seed is of high nutritional quality and contains 23 % to 34 % protein (Newton & Hill, 1983). It is used extensively in human diets in the Mediterranean region. ICARDA (1985) estimated annual per capita consumption to be 9 kg in Egypt and 12 kg in the Sudan. Virtually all Egyptians eat it every week with 34 % of rural dwellers and 73 % of city dwellers eating it seven times a week. Besides their use in human diets they can comprise an important protein supplement in rations for monogastric animals (Newton & Hill, 1983).

Claridge (1972) did not list *Vicia faba* among his miscellaneous legume crops in his book on *"Arable Farm Crops of New Zealand"*. Similarly when Newton (1980) commenced her research on the crop she could find little previous published work on the species in New Zealand. Logan (1983) suggested that from 1971 to 1981 200 to 500 ha of broad beans were grown each year. The latest statistics indicate that 75.7 ha of broad beans were grown in New Zealand in 1988 (Department of Statistics, 1989). However, they do not make it clear if those were for fresh vegetables alone or combined vegetable production with beans for processing. As dry tick are mainly grown under contract and statistics are not collected for them the areas sown to them are not readily obtainable.

Given the lack of information on the crop in Canterbury, Newton & Hill (1978), conducted a survey of Canterbury farmers growing *Vicia faba* during the 1977-78 growing season. The total area surveyed was 200 ha. They found that the average seed yield was 2.59 t/ha (range 0.07 t to 6.2 t). Few farmers inoculated their seed, which was sown at an average population of 43 plants/m² (range 27 to 92 plants/m²). The mean sowing date was the last week in June but sowings ranged from 1 May to 2 October.

The most worrying feature of their survey however, was the high incidence of the seed borne disease *Ascochyta fabae*. On some farms up to 100 % of plants were infected and the minimum degree of infection found on any farm was 20.0 %. Visible infection on seeds ranged from 1 % to 55 %. Work by Newton (1980), Husain (1984) and Attiya (1985) would suggest that many of the practices followed by farmers in 1977-78 were likely to ensure poor crop yields.

AGRONOMY

Seed health: Given that the disease *Ascochyta fabae* is seed borne an effective and cheap method of disease control is to only sow seed which has been tested for the disease and to only sow seed lines that have less than a recommended level of infected seeds. Gaunt *et al.* (1978) suggested that seed with more than 0.1 % infection should not be sown. Gaunt & Liew (1981) considered that seed selection was the most cost effective control method but it should be supported by use of a fungicidal seed dressing as a cheap insurance. It was their hope that following the recommendations that *Ascochyta fabae* would cease to be a problem in Canterbury.

Sowing date: Very early work by Newton & Hill (1977) showed that considerably higher yields were obtained from autumn sown than from spring sown field beans. The maximum yield from autumn sown Maris Bead was 4.3 t/ha. In the spring sowing the maximum yield was 2.2 t/ha. Autumn sown plants commenced flowering at an earlier node and carried pods over a wider range of nodes. In a later trial (Newton & Hill, 1987) the mean yield of irrigated autumn sown plants was 5.3 t/ha. Mean yield for irrigated spring sown plants was only 2.7 t/ha. When sowing in spring was delayed to late September spring yields fell from 3.0 t to 1.4 t/ha. Similarly Husain *et al.* (1988) over two year obtained an average seed yield of 4.6 t/ha from autumn sown crops and 2.9 t/ha from spring sowings. It is therefore most important that if *Vicia faba* is to be grown that crops are sown as early as possible and it appeared that many of the farmers surveyed by Newton & Hill (1978) were reducing crop yield by late sowing.

Plant population: As with time of sowing plant population has a major effect on yield in field beans. In both spring and autumn sown Maris Bead and Daffa there was a linear increase in seed yield as population increased from 25 to 75 plants/m^2. In autumn yield increased by 2.5 g/m^2 for each extra plant. However in spring the increase was considerably less at 0.7 g/m^2 per plant. Further, the response of Daffa to increased population in spring was considerably less than that of Maris Bead. Again in their later experiments Newton & Hill (1987) obtained a linear increases in dry matter production and seed yield with increased plant population. Attiya *et al.* (1983) did not obtain increased seed production in response to population from a spring sowing of but their yields 3.1 t/ha were high for a spring sowing.

Seed bed preparation: Newton (1980) suggested that *Vicia faba* did not have a high fertility requirement. It is recommended that they be sown with maintenance levels of superphosphate. It also seems that there are usually sufficient Rhizobia present in New Zealand cropping soils to nodulate field beans without inoculation. The seed are large and Maris Bead which is regarded as a small seeded cultivar has a mean seed weight of 350 mg. Field beans do not require a fine seedbed and in common with other large seeded legumes should be sown at about 5 cm. They are also not tolerant of soil compaction and the leaving of tramlines should be considered where the crop may have to be sprayed after emergence. Simazine at 1.3 kg a.i./ha combined with a plant population of about 70 plants/m^2 seems to provide reasonable weed control.

Irrigation: *Vicia faba* is a crop that responds well to irrigation. Newton & Hill (1987) using a gravimetric method to assess crop water requirement increased the yield of autumn sown crops from 3.8 t/ha to 5.3 t/ha and spring sown field beans from 1.8 t/ha to 2.7 t/ha. Husain *et al.* (1983) applied water according to crop demand based on calculated evapotranspiration. Their results confirmed that irrigation could increase the yield of both spring and autumn sown crops by 45 %. As with the work of Newton & Hill (1987) the response to irrigation was far greater in the autumn sowings than in the spring sowings. Over two years the mean increase in seed yield was 6 kg of seed/mm of water applied in autumn and 4 kg/mm in spring. However, it is notable that even in a wet year (1983-84) Attiya (1985) increased the yield of a spring sowing from 1.8 t/ha to 2.6 t/ha. In none of the trials did irrigation bring the yield of a spring crop up to that of an unirrigated autumn crop and given the increased response to irrigation from the latter it is more economic to irrigate autumn crops.

Plant pests and diseases: The major disease of *Vicia faba* in New Zealand appears to be *Ascochyta fabae*. The main control method of the disease is prevention (as discussed above). Janson (1984) reported *Botrytis cinerea* and *Uromyces vicae-fabae* were a problem in late summer sown tick beans in mid-winter. The aphid *Aphis craccivora* has been reported to infest *Vicia faba* but is not considered to transmit subterannean clover red leaf virus (Wilson & Close, 1967, cited by Newton, 1980)

NITROGEN TRANSFER

Janson & Knight (1980) and Janson (1984) investigated the potential of *Vicia faba* to provide forage for sheep in the winter and nitrogen for a succeeding spring wheat crop. In the first season the plants were sown at the end of the first week in March. They produced 4.4 t/ha of forage which was 69 % utilised when grazed in mid August. By October the forage on offer was 6.6 t/ha but utilisation fell to 59 %. Yield of the following spring wheat crop after tick beans was 3.75 t/ha compared with 1.6 t/ha from the control (Janson & Knight, 1980). In a second trial the tick beans were sown in February and March and forage yield was reduced by disease and frost damage in winter. However, spring wheat yields were still increased after the crop was either grazed just before sowing (6.0 t/ha) or ploughed in six weeks before sowing (4.9 t/ha) compared with the control of winter fallow (4.1 t/ha).

Newton & Hill (1981) measured the amount of nitrogen in a standing *Vicia faba* crop and estimated the nitrogen harvest index. It was considerably higher than the harvest index for seed with a mean value in autumn of 58 % (seed HI 32 %) and in spring of 50 % (seed HI 25 %). Their results suggest depending on cultivar and sowing time that between 42 kg N/ha could be returned to the system following harvest of a spring crop and 112 kg N/ha following harvest of an autumn sown crop which usually produces considerably more dry matter. There have been no experiments in New Zealand which have attempted to measure the nitrogen return from a harvested *Vicia faba*

FUTURE POTENTIAL

At the present moment the potential for this crop in New Zealand appears to be limited. However, because of its ability to grow in winter on soils with a high water content it tend to compliment rather than be in opposition to crops such as peas and lupins. Because potential markets can arise at any time it is important that New Zealand continues to import and evaluate the latest cultivars. Recently Jones *et al.* (1989) evaluated a range of new winter and spring cultivars from the United Kingdom. A number produced significantly more dry matter than currently available lines and one, Banner Winter, produced the equivalent of 4.4 t/ha compared with Maris Bead at 4.1 t/ha. There is no doubt that we now have a considerable knowledge as to how to grow this crop in New Zealand, all that is needed are the markets. Perhaps we can tap the Egyptian market where the demand is high and available land which can be irrigated is finite.

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GRAIN LEGUMES IN SUSTAINABLE CROPPING SYSTEMS: A REVIEW

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ABSTRACT

The importance of nitrogen fixation and nitrogen addition to soils is discussed and the effects of different grain legume species and other factors on nitrogen fixation are reviewed. The addition of nitrogen to soil and its availability following crops is also discussed. The importance of grain legumes as break crops, and the positive effects of other crops on grain legumes in sustainable systems is described.

Additional Key Words: *break crop, chickpeas, crop rotation, faba beans, grain legumes, lentils, lupins, nitrogen fixation, peas,* Phaseolus *beans, sustainable systems*

INTRODUCTION

In New Zealand, grain legumes are grown in rotations with crops such as wheat, barley, grass seed, and white clover seed. In recent years there has been a strong emphasis on high input-high yield systems, although New Zealand cropping farmers have not moved as far towards capital-intensive continuous cropping systems as have farmers in countries such as the United States and Great Britain.

Concern about the sustainability of such intensive systems caused the United States Congress to pass an act in 1985 to provide authority to conduct research and education programmes into alternative farming systems, now known as LISA, or Low-Input Sustainable Agriculture. These systems seek to maintain high land productivity, but to use techniques that minimise the use of pesticides, fertilisers, and off-farm purchases through appropriate rotations, biological weed, pest, and disease control, integration of livestock with crops, and minimum tillage systems.

In 1988 a major research and extension effort commenced in the United States to provide information on such systems to reduce costs, control erosion, and abate pollution from heavy fertiliser and pesticide use and from monoculture cropping systems.

In New Zealand there is also increasing interest in lower input sustainable agricultural systems on cropping farms, particularly from the economic view, to reduce the costs of production.

At the same time there is increasing public concern about the possibility of undesirable chemical residues from farming affecting ground water and streams, or of chemical residues on the saleable produce. However, present New Zealand arable farming systems produce fewer of the problems which occur overseas although major problems of wind erosion in the 1987-89 drought are causing cropping farmers to seek improved soil management practices and greater efficiency of water use.

Lower input sustainable systems do not mean that we should return to agricultural practices of the 1940's, or that we should change to organic systems where chemicals are not used at all. Rather, low input sustainable systems require a farmer to understand more about the biological effects of a crop or management systems and how this information can be used cheaply and effectively in farm programmes, e.g., integrated pest management.

Grain legumes are of particular importance in such systems, as they are capable of fixing nitrogen or breaking cycles of diseases and pests which affect other crops.

CONTRIBUTION OF GRAIN LEGUMES TO LOW-INPUT SUSTAINABLE SYSTEMS

The main objective in growing a grain legume crop is to obtain a high net return, but in the process several positive contributions can be made by this crop to the following crops in the systems.

***Nitrogen fixation and nitrogen addition to soil*:** Most grain legume crops fix significant amounts of nitrogen symbiotically, thus obviating the need to supply fertiliser nitrogen. Some species also add sufficient nitrogen to the soil to supply part of the nitrogen needs of a following crop.

The rate of nitrogen fixation is slow during early vegetative growth, when soil mineral nitrogen sources may be sufficient for crop requirements, but increases later parallel with the crop growth rate. Maximum rates are reached during flowering and early pod fill, and may continue for some time at this level if these processes are prolonged e.g. in indeterminate cultivars. A rapid decline in nitrogen fixation coincides with decreased crop growth rate, decreased green leaf area, lodging, and the initiation of translocation of N from vegetative organs to seed (Rhodes *et al.*, 1982; Askin *et al.*, 1986; Zapata *et al.*, 1987; Jensen 1989).

***Nitrogen fixation by different grain legume species* :** Grain legumes vary widely in their ability to fix atmospheric nitrogen due both to species differences and the field conditions under which they are grown. However, clear trends are apparent in Table 1 with lupins and faba beans fixing the highest amounts of nitrogen, followed by peas and lentils, chickpeas, and soya beans. Peas, our main grain legume have not been measured to fix more than 75 kg/ha in New Zealand (Askin, 1983). However, field peas grown under irrigation in Canada have fixed double this amount (Rennie & Dubetz, 1986), while high yielding pea crops in Denmark (5.0 t/ha) fixed a mean of 208 kg N/ha over four years of experimental work (Jensen, 1986, 1989).

There are less data available on nitrogen fixation by lentils and chickpeas than for other grain legumes. Soya beans only fix half their total plant nitrogen, while *Phaseolus* beans are generally poor at nitrogen fixation due to poor symbiosis and often a low genetic ability to fix nitrogen (Graham, 1981; Pika & Munns, 1987). Early maturing bush types are weakest, and indeterminate climbers are best.

Most *Phaseolus* beans grown for processing in New Zealand receive fertiliser nitrogen as their main source of this nutrient, and few or no nodules are found on their roots.

Table 1: Estimates of nitrogen fixed by different grain legume species.

Legume species	Amount fixed (kg/ha)	Source
Lupins	175	Rhodes (1980)
	252	Herridge (1982)
	60	Smith *et al.* (1987)
	217-225	Herridge & Doyle (1988)
	193-247	Larsen *et al.* (1989)
Faba beans	235	Day *et al.* (1979)
	216 (179-252)	Rennie & Dubetz (1986)
	80	Smith *et al.* (1987)
	209	Zapata *et al.* (1987)
	160	Bremer *et al.* (1988)
	230	Jung *et al.* (1989)
Peas	17-69	Mahler *et al.* (1979)
	65	Rhodes (1980)
	75	Askin (1983)
	185 (174-196)	Rennie & Dubetz (1986)
	60-80	Smith *et al.* (1987)
	105	Bremer *et al.* (1988)
	208	Jensen (1989)
Lentils	10-129	ICARDA (1983)
	176 (162-190)	Rennie & Dubetz (1986)
	80	Smith *et al.* (1987)
	75	Bremer *et al.* (1988)
Chickpeas	14-120	ICARDA (1983)
	54 (24-84)	Rennie & Dubetz (1986)
	10	Smith *et al.* (1987)
Soya beans	75-90 (50 % of total N)	LaRue & Patterson (1981)
***Phaseolus* beans**		
	24-65 (37-68 % of total N)	Ruschel *et al.* (1982)
	40-125 (50 %)	Rennie & Kemp (1983)
	20-115	Graham & Temple (1984)
White clover seed		
	220	Whelan & White (1985)

For all grain legumes except for lupins and faba beans, these estimates of nitrogen fixation are on average much lower than those reported for white clover in a grazed pasture (Hoglund & Brock, 1978) or grown as a seed crop (Whelan & White, 1985).

Factors affecting the level of nitrogen fixed within a species: The circumstances where grain legumes are likely to fix high levels of symbiotic N are well known, and it is important to create these conditions in the field wherever possible.

A fundamental requirement is the presence of effective strains of *Rhizobium* and for a number of legumes in New Zealand it is necessary to add these as inoculum on seed, e.g., soya bean, and chickpeas. Although *Phaseolus* beans are not inoculated in N.Z. there is now a realisation that both strains of rhizobia and cultivars of beans need to be selected with improved *Rhizobium* strain-host symbiosis and increased nitrogen fixing ability (Graham, 1981) so that reliance on fertiliser nitrogen can be reduced or eliminated.

Grain legumes will use soil mineral nitrogen or fertiliser nitrogen if it is available, in preference to fixing their own. Consequently, fixation of N is likely to be greatest when the legume follows a soil N depleting crop such as wheat, barley, or ryegrass seed, and lowest when following pasture or a clover seed crop. In fact, where soil mineral N levels are very high the grain legume may obtain almost all its requirements from the soil and virtually none from fixation, resulting in a net reduction in total soil nitrogen. Faba beans are more tolerant of soil mineral N than other species and will still fix large quantities of N when mineral N is present (Roughley *et al.*, 1983). This is because faba beans have a lower N fertiliser utilisation efficiency (Chalifour & Nelson, 1988) together with a high potential to accumulate nitrogen.

The period over which a crop grows also affects the amount of nitrogen fixed. Autumn or winter sown legumes generally fix more N than spring-sown crops because they are growing for longer, and often in moister soil conditions which are better suited to optimum N fixation (Askin, *et al.*, 1986; Keatinge, *et al.*, 1988; Wery, *et al.*, 1988). Peas harvested for vining fix less than the same cultivar when taken for seed because the crop is taken while fixation is still continuing (Askin, 1983).

The nutrition, soil physical conditions, and moisture regime of the crop also influences N fixation, and crops that are adequately fertilised, and with good soil aeration and adequate soil moisture will fix nitrogen at a higher level or over a longer period. Canadian work has shown that nitrogen fixation by lentils, peas and faba beans declined by an average of 5.3, 7.6 and 10.5 kg N/ha for every 10 mm reduction in moisture use. Under drought-stressed conditions peas and lentils were more efficient in nitrogen fixation than faba beans (Bremer, *et al.*, 1988).

Genetic differences exist among cultivars in their ability to fix N. Generally, indeterminate cultivars fix more N than those with a determinate growth habit, e.g., climbing beans (Pika & Munns, 1987), Austrian winter pea (Smith *et al.*, 1987). In New Zealand, Askin, *et al.* (1986) found that field peas, particularly Maple peas, had higher rates of nitrogen fixation than garden peas. They suggest that this was genetic in origin and that there may be scope in plant breeding to exploit these differences.

Addition of nitrogen to the soil and availability to the following crop: Grain legumes generally leave the soil in a higher state of soil fertility than cereal crops, particularly in terms of the amount of soil mineral nitrogen available to following crops (Rhodes, 1980; Askin, *et al.*, 1986; Jensen, 1989) (Table 2). However, there are large differences in the amounts made available by grain legume species or by different management systems.

Table 2: Nitrogen uptake in winter ryegrass (Rhodes, 1980) and winter barley (Jensen, 1989) succeeding peas or a cereal.

	Nitrogen uptake (kg N/ha)	
Preceding crop	Winter ryegrass	Winter barley
Peas	66	89
Cereal	36	43

As grain legumes mature there is a rapid translocation of nitrogen from stems, leaves, and pods into the seed. Large amounts of nitrogen are removed when this seed is harvested, in many cases equalling or exceeding all of the N which is fixed (Tables 2, 3). In peas, lentils and chickpeas, all that can be expected is that the amount of N fixed is equal to that removed in the grain (Table 4). Where nitrogen fixation is suboptimal in these crops, the balance is obtained from soil mineral N which will deplete total soil nitrogen. Crops of soya beans and *Phaseolus* beans will almost always result in a net loss of soil nitrogen. It is only in lupins and faba beans where fixation normally exceeds the amount removed in seed (Table 5).

Table 3: Nitrogen removed in seed from an average grain legume crop.

Species	Yield (t/ha)	N in grain (%)	Total N removed (kg/ha)
Dry peas	3.5	3.5	123
Green peas (vined)	6.0	5.0 (on DM basis)	50
Lentils	2.0	4.0	80
Lupins	3.5	5.5	193
Faba beans	4.0	4.0	160

Lupins are widely used in crop rotations in Australia as a significant and sometimes the only sources of nitrogen for following wheat crops. Increases in yields of cereals grown after lupins range from 30 - 100 % when compared to wheat monoculture (Rowland, *et al.*, 1986).

The total amount of nitrogen returned in crop residues and roots is generally much greater than the amount taken up by an immediate following crop (Table 5). In many grain legumes the nitrogen harvest index (NHI), i.e. the proportion of total above-ground N which occurs in the seed, is very high, of the order of 80 - 90 % (Askin, *et al.*, 1986; Larsen, *et al.*, 1989). Crop residues may therefore only contribute a small amount of nitrogen when returned to the soil. In addition, their nitrogen content may be low (e.g. peas 1.28 % N, (Jensen, 1989)) resulting in little net mineralisation for many months. The nitrogen from these residues (< 1.3 - 1.5 % N) is not readily available for a succeeding crop but will contribute to the more stable pools of soil organic matter, thus benefiting future crops in the rotation.

It is the roots and root nodules of grain legumes which are likely to be the greatest source of N for following crops (Dyke & Prew, 1983). These plant parts are higher in nitrogen content (e.g. peas, 2.5 % N, (Jensen, 1989)) and decompose quickly, releasing mineral nitrogen in a few weeks (Askin, 1985; Jensen, 1989).

Table 4: Nitrogen balance for a pea crop (Jensen, 1989).

Parameter	kg N/ha (4 year mean)
Total crop N	283
N_2 fixation	208 (73 %)
N from soil	75
N in seed	217
N in straw (returned)	66
Soil N gain or loss	-9

Table 5: Fixed nitrogen supplied by a grain legume to a following crop.

Species	Amount supplied (kg/ha)	Source
Lupins		
	25	Rhodes (1980)
	80	Herridge (1982)
	41	Reeves *et al.* (1984)
	37	Rowlands *et al.* (1988)
	37	Doyle *et al.* (1988)
Faba beans		
	44-50	Dyke & Prew (1983)
	18	Jung *et al.* (1989)
Green manure peas		
	26	Mahler & Auld (1989)
Grazed lupins		
	76	McKenzie & Hill (1984)

Green tops of legumes breakdown similarly. For example, vining peas have a low NHI of 50 % or less because they are harvested before translocation of N to the seed is completed. When returned to the soil the green vines are a significant source of nitrogen and are mineralised rapidly.

Grain legumes may be grown as a forage for animals (Janson & Knight, 1980; Janson, 1984; McKenzie & Hill, 1984) or as a green manure, and can add large amounts of nitrogen to the soil. In either case, lupins or faba beans are likely to fix more nitrogen and add greater amounts to the soil than other grain legumes. In higher fertility soils the proportion of nitrogen derived from fixation may also be enhanced by growing the forage or green manure legume with a non-leguminous companion crop such as ryegrass or oats to utilise soil mineral nitrogen (Danso *et al.*, 1987).

Because a significant proportion of nitrogen added to the soil by grain legumes is mineralised in the few weeks following harvest, it is important to avoid losses of this nitrogen from the plant-soil system. The principal losses are through leaching of nitrate, and denitrification (Jensen, 1989). If no crop is established in the autumn and the land is left fallow until the following spring then most of this nitrogen may be lost. Autumn-winter sowings of ryegrass seed, winter wheat or winter barley will minimise these losses, but if these are not planned, then a nitrogen catch crop of greenfeed ryegrass or cereal should be used between the harvested grain legume and the spring crop (Table 6).

Table 6: The effect of white mustard as a N catch crop on grain yield and nitrogen uptake of spring barley when following peas (Jensen, 1989).

N catch crop	Barley grain yield (t/ha)	Nitrogen uptake (kg N/ha)
-	4.7	87
+	5.3	104

Break crop: Grain legumes are highly regarded as an important and beneficial break crop. They are particularly valuable in reducing disease and pest infestation of following cereals because the legume is not a host of most cereal pathogens. For example, take-all (*Gaeumannomyces graminis*) in wheat can be greatly reduced by a previous legume grain crop (Reeves, *et al.*, 1984; Gardner & McDonald, 1988; Rowlands, *et al.*, 1988), while other diseases such as eyespot (*Pseudocercosporella*) are also minimised. In Australia, a 14 % increase in wheat yield has been measured where wheat was preceded by lupins, due to reduced incidence of take-all (Gardner & McDonald, 1988).

Certain problem grass weeds in cereals can also be controlled by growing a legume in rotation. Ripgut brome (*Bromus rigidus*) is a problem weed in wheat crops in both western Oregon in the United States, and in southern Australia and cannot easily be controlled with chemicals. However, the seed survives for less than 12 months in soil, (Gleichsner & Appleby, 1989), and by rotating wheat with peas, excellent long-term control of the brome has been obtained by the use of herbicides on the pea crop (Appleby, pers. com.).

Stubbles for grazing: Compared to cereal stubbles, grain legumes stubbles are of relatively high value for grazing with livestock after harvest. This is not only the stems and leaves, but includes any unharvested grain.V ining pea stubbles are particularly valuable as the vines are relatively high in protein compared to threshed peas.

POSITIVE EFFECTS OF OTHER CROPS ON GRAIN LEGUMES

A number of other crops, if grown before a grain legume crop, can have a positive effect on grain yield or nitrogen fixation of the legume.

Reduced disease incidence: Continuous grain legume cropping is rarely practiced because of fungal diseases, particularly those that are soil borne, which can increase rapidly and cause major reduction in yield.

The root rot complex caused by the organisms *Aphanomyces euteiches* and *Fusarium solani* is economically very important in both peas and lentils. No disease resistant genotypes have yet been developed commercially (Davis & Shehata, 1986; J. Kraft, pers. comm., 1989) and control of these and other diseases such as *Ascochyta* is largely by maintaining at least a five year gap between successive pea and lentil crops.

In fact, all grain legume species should be regarded as the same crop when planning cropping sequences in order to minimise heavy loss from soil-borne pathogens (Salt & Delaney, 1986).

Recently Chan & Close (1987), at Lincoln, measured significant reductions in the incidence of *Aphanomyces* root rot in peas where cruciferous crops such as rape, mustard, fodder radish, and kale preceded the peas. Even where only roots were incorporated into the soil, disease severity was reduced by 41 %. The cause of the reduction in disease is likely to be due to sulphur-containing volatiles such as isothiocyanates which are produced on decomposition of the brassica crop and which are known to be extremely toxic to *Aphanomyces*: At the University of Idaho, in the United States, Dr D.L. Auld is breeding rapes with high isothiocyanate content which may reduce nematode as well as *Aphanomyces* levels in soil. Using brassica crops before peas or lentils in cropping rotation is thus an important way of reducing the incidence of *Aphanomyces* root rot.

Weed control: Compared to cereals, most grain legumes are poor competitors with weeds and yields are generally increased by good chemical weed control. Because the worst weeds are broadleafed, cost of control can sometimes be high, e.g., Californian thistle. The incidence of such weeds in grain legumes can be kept low by growing alternative crops such as cereals in a rotation, and using wide-spectrum cheaper chemicals for their control in those crops.

Soil physical condition: Most grain legumes suffer reduced yields if soils are compacted and poorly aerated. Vining pea yields can be reduced up to 70 % by soil compaction, which reduces seedling emergence, root growth, and water extraction of the peas (Dawkins & McGowan, 1986). Good soil structure produced by growing ryegrass seed crops or pasture before a grain legume will reduce these problems, particularly if combined with minimal and timely cultivation practices to conserve this good structure.

CONCLUSIONS

The practice of lower input sustainable agricultural systems requires a good understanding by the farmer of the effects of one crop upon another and how beneficial effects may be managed to greatest advantage but at low cost. This review summarises our present knowledge of the positive effects of grain legumes in cropping systems, particularly the nitrogen economy, and the benefits of previous crops on grain legumes. These approaches are not new, but if they are practiced in an integrated way, they will reduce the need for nitrogen fertiliser and pesticides, thus reducing costs of production, while maintaining or even increasing the yield of grain legumes.

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REPORTS FROM WORKSHOPS - REVIEW OF ALL SESSIONS

Convenor - H. Blain

One of the things that struck me is the similarities between the United States and New Zealand industries and the difficulties with prioritising where you should be going with research, because I find that is a very difficult problem with our industry as well.

In the grain legume field there are still a lot of unknowns; disease control is very important and there are still large gaps that need to be addressed; we need to look at farming systems and determine how that crop fits into the farming system as far as rotation is concerned. There are signals from the feed industry that we should identify three agronomically suitable crops that would fit in with the rotation, possibly one in the North Island and two in the South Island.

The cost factor is very important as far as the feed industry is concerned and high yield is important. Any crop has to be important for the farmer too. If you have a crop that is not going to be profitable to the farmer then it's not going to be grown. There is a need to evaluate price as well as the marketability of the particular crop.

One of the things that was discussed was the lack of good market information. Particularly the need to know what the markets are before we develop the varieties, instead of developing varieties and then hoping we can find a market for it. Research is a long range activity and the feeling is that on some projects we have got a good start but we need to proceed further as, for example, with aphanomyces and different management techniques that might be able to allow us to control disease until such time as resistant varieties are found.

I think another thing that was pointed out is that research programmes need to co-operate with researchers in other countries and probably New Zealand does as good a job as anybody, better than the United States, but that needs to be continued. But I think it's important to network with all researchers and personal contact is very important. For my own purposes, it is much more important to me being here at this conference than to just receive the results.

We discussed the long range industry plan that we need to look at as far as research is concerned. The United States industry went through a similar exercise last spring as to where the industry was to be five years from now. I understand there is been some of this done at Lincoln but I think it is very important to see where you are going five years from now because research is not a year to year thing. It is at least a three year commitment and is usually a five year programme.

One thing pointed out was the need for better representation from merchants and farmers. There was some disappointment at the small number of farmers and merchants that we had at this conference. Efforts should be made to develop a better relationship between the merchants and farmers and possibly there is an opportunity now to build on this conference and see if you can not get a better working relationship between the various sectors of your industry.

One other thing that was pointed out is the lack of statistics on legume crops. It was noted that there is a Government survey that maybe could be expanded on to get the type of information that I think is absolutely necessary from both a research and a marketing standpoint.

Convenor - Nicky Jenkins

Our discussion centred on identifying the market, how the market can be met, what research was required, what was the best way to get the industry up on its feet and what actions should be taken as a result of this symposium.

The domestic livestock feed market seemed to have a great deal of potential and there the major aim seemed to be to increase the yield of cultivars dedicated for feed production. We discussed whether there should be a payment for grain legumes on a unit protein basis. Processors identify crops such as lupins and faba beans as being the preferred types because they are not linked into a secondary industry such as soya beans which are linked into the oil industry.

We also considered the need to expand the land area devoted to grain legumes taking into account the varying requirements particular crops. Grain legume research has been concentrated around the Canterbury area, particularly Lincoln and this could well bias farmer attitudes towards the crops and there could be great potential in conducting more research and development in the North Island.

Aphanomyces is currently a limiting factor in reducing the land available for grain legume crops, research on crop rotations such as the incorporation of brassicas in the rotation, and aphanomyces disease resistance may also be very helpful in increasing the land area available.

The next issue we considered, was who should be responsible for taking a lead in the development of the feed market. We felt that processors could give a lead by providing forward contracts and also by helping to identify the markets. Processors have identified a potential for replacing meat meal with vegetable protein. However, forward contracts on a fixed price basis may not be totally acceptable to growers. Growers like to have flexibility of contract options so that they can weigh up the risks involved from the export market against a guaranteed return locally. There was also some discussion on the extent to which uncommitted (free) peas are being grown this year. When the financial situation is better, farmers are prepared to take the risk which they wont in more difficult times.

We identified a timing constraint in getting contracting underway due to processors getting linked into importing. Thus an immediate response is required. It was agreed that it should be an industry approach and that all the sectors had something to gain from getting the industry up and running. However, if you include all the players, we would probably get out of control and end up being unproductive. So the idea was to liaze with the industry and set up a task force which identified general items arising from this symposium and having identified these items, then call a greater industry meeting to get some action underway.

We ruled out targeting the retail end of the market. We decided the commodity side was probably the better priority at this stage. We felt that there was a lot growers could do to improve the attitude of other growers to extend land areas through education and improving grower confidence by providing management advice to growers. Processors felt that they couldn't really consider an agronomic backup system similar to Wattie Frozen Foods because the commodity just does not justify that sort of involvement. However, there was very definitely a contribution to be made by the grain trade in providing management support so that growers can be persuaded that it is not too difficult to grow grain legumes.

We also agreed that there was a need for more statistical information and that we should be getting the Statistics Department to actively promote the benefits from accurately completing farmer surveys.

We also talked about the way Americans get information on seed sowing from the merchants and it seems that it is feasible, perhaps, to get information on lentils that way because there are only two merchants handling lentils. We could start off the system with lentils and then maybe expand it to other species. But there is definitely a problem for peas with the amount of seed that is saved by farmers for use on the farm.

The final question we addressed was "Who's going to get all of this underway?" The group decided that it should be Federated Farmers, so I will be looking for assistance!

Convenor - W.A. Jermyn

Our group felt that there were strong similarities between the New Zealand industry and the American industry as determined by the American Dried Pea and Lentil Association (ADPLA) experience. We see New Zealand as being towards the high value, added-value end of the market, closer to the American scene than the Australian scene.

The specific recommendation that we wish to carry forward to a task force, is that the nutritional aspects are a key area for future research. This will of necessity involve biotechnology; but very certainly it came through from the session yesterday as being where grain legume research is deficient. A benefit of biotechnology has been in enhancing substantially, rather than contributing to, the environmental worries that people legitimately have about multiplication of plants and organisms.

We identified two other research areas as being important. One comes down to sustainable agriculture and that includes basic management research on how to do the simple things well.

The other, on which we agreed with Harold Blain, was that there are some grain legume alternatives around but that their value within the rotation needs to be looked at as well as their profitability. There is also a need for information on the relative values of all the legume feed options.

The group felt that lack of markets was not a constraint. The problem that everyone has identified is lack of product to fill existing markets, specifically processed peas, red lentils, vegetable grain legumes for freezing and soya beans.

When it came to trying to formulate some recommendations as to an industry approach, or structure, we struck a vacuum. We endorsed the need for a forum. We need to start with market information, stocks information and production information. We wondered if that information provision might be a job contracted out to an existing bodies such as, Federated Farmers who have a newsletter, DSIR Crops, or a seed firm, or an exporter. We need to examine the feasibility of a new structure like the ADPLA which has as its focus, information exchange, new cultivar promotion, and the enhancement of research. The marketing needs to be left to the industry.

We would like to see the recommendations from this workshop go to MPs, MAF, MORST, MERT, DSIR, NZ Grain and Seed Trade Association, Pesticides Board, Grocery Manufacturers Association and Watties. There is enormous unused potential for a feed processor and other processors in our industry to use that facility to add value to our existing crops.

Question: I just wanted to question the comments Professor Field made about making recommendations to MPs, government departments etc. To what extent should we still be relying on the Government to help us or should it be up to the industry to get its act together and get together themselves?

Answer: I think that it is certainly up to the industry to provide the leadership, but the government also has a role in helping those who are seen to be helping themselves. I think we would all agree that we can't depend on them for anything.

Comment: It seems to me that this industry should really be trying to tap the Medical Research Council funds with improved dietary procedures and the viability of this material. It has become apparent that one of the outcomes that the DSIR is contracted with the Government to provide, is improved human health. It seems in the grain legumes we have an enormous opportunity to enhance the Government's wish to improve human health and we're just not making the best use of what we have before us.

Comment: I don't know how strong the environmental groups are in New Zealand, in the United States they have become extremely strong. They are not only very vocal but they are very well financed and what we are trying to programme right now is because one of their main objectives is to eliminate all fertilizers and chemicals and this type of thing. So what I would say is, instead of being defensive, which we have been, we have got to go to them and say, look, if you want us to find better substitutes then how about funding research projects that help us eliminate the amount of chemicals we are using (or erase them); because they have some very good sources of finance which they use primarily for legal purposes. Encourage them to take a lead in funding some of this research.

Question: In the value added area of legume processing, how does Watties see itself getting involved?

Answer: I do not think Watties are short of markets, we want the product and we could sell it.

Question: Is product supply a major limitation?

Answer: Yes, a number of new crops we could sell tomorrow, we just do not have the product.

Comment: We have in place now, a system where growers are asked to keep a pesticides diary as we have continual enquiries from Japan. We are compiling a pesticides residue register for our company. They are the sorts of questions a lot of our customers are asking for now. They want to know what fertiliser we have put on, what herbicides, insecticides etc. and we have got to assure them that it's been proven.

The dry pea market will probably not be too far behind the fresh market in regard to information requirements about possible residues in the product.

Question: I wonder if there's been a breakdown in communication between Watties and the growers, given the requirement for product and presumably unfilled contracts. Or is Watties not taking it to the growers?

Question: One of the problems is we just have not been able to find enough pea growers this year, our understanding is that the growers just didn't want to accept the risk of losing the crop with last year's drought and the downy mildew disease problem. Even though we increased the price quite considerably for late peas we still aren't able to fill our requirements, probably because by that time growers had chosen other options?

Comment: I am a grower and we are moving into some crops and we found that we can not find seed sources. We approached Yates and Pyne Gould and DSIR Crop Research and in no case could we find seed. I eventually had to go to a health food wholesaler just to buy my seed supply which is less than ideal. This is for chickpeas, red kidney and soya beans.

Answer: It has come up over the last two days that a lot of alternatives are available, but they're being strangled because the seed supply is not there even though there is a market. Also one of the reasons that the pea acreages have declined is a shortage of peas for seed over the last couple of years.

I think one of the problems with a traditional crop is that you have merchants handling these crops on commission or brokerage which means its only when they get a volume of through put that they get the returns they require. You do not get that in the developmental stages and if they are not assured of recovering their costs they may not be interested in taking it through. Or if they cannot capture those markets for themselves, other merchants who have played no part in developing it, then come in and cash in on their investment. So there is a threshold where the costs are growing and there are few returns. This is a typical problem facing any innovator trying to establish or develop a new business.

Question: Would anyone like to comment on that? How are we going to facilitate the early stages of developing new crops? It has been suggested that individuals are unlikely to do it if they can't capture a return.

Answer: You can actually receive funding from the Regional Development Councils - it is a source of up to 50 % funding on certain projects. They seem willing to accept the difficulties and provide assistance in the early stages. The other thing that may help to retain a market advantage is to inject funds at the pre-commercial stage and retain control for longer through contracting to purchase all produce. The other option is to do the development collectively either through levies or specific consortia set up for that purpose.

WATER, FUNGICIDES AND HOST RESISTANCE AFFECT DEVELOPMENT OF *ERYSIPHE PISI* ON PEA LEAVES; AN ELECTRON MICROSCOPE STUDY

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INTRODUCTION

Powdery mildew of peas *(Pisum sativum* L., caused by the fungus *Erysiphe pisi* DC. ex St-Am., occurs worldwide, and has prevented or limited pea production in many countries (Dixon, 1978). Severe epidemics of the disease have recently occurred in New Zealand, possibly due to dry, warm weather conditions (Falloon *et al.*, 1989a). The disease in green pea crops disrupts harvesting and reduces crop yield and quality, while effective fungicide control is costly (Falloon *et al.*, 1989a). Cryo-fixation techniques and the scanning electron microscope have been used to study morphology of *E. pisi* on pea leaves, and effects of water, fungicides and host resistance on development of the fungus.

METHODS

On a susceptible host (cv. 'Pania'), germinated conidia of *E. pisi* possessed single primary appressoria, and later developed hyphae radiating outwards across the host epidermis. Hyphae grew uni-directionally across leaves. Six days after inoculation, many hyphae were seen on leaf surfaces, and conidiophore development had begun. By 14 days, leaf surfaces were covered with powdery mildew colonies, consisting of surface hyphae, conidiophores and conidia. Morphology of *E. pisi* has been described in detail elsewhere (Falloon *et al.*, 1989).

Spraying distilled water onto leaves caused collapse of many hyphae while others appeared normal, and impact of water droplets caused severe disruption of colonies. Four days after water application, many abnormal outgrowths were observed on hyphae. Spraying leaves with triazole fungicides caused disruption of colonies and general collapse of conidia and hyphae. On a resistant host (cv. 'Bounty'), conidium germination and early growth of hyphae were similar to that on 'Pania', but by 14 days after inoculation, conidia and hyphae had collapsed and no normal *E. pisi* tissue was seen.

RESULTS

Observed effects of water on *E. pisi* may explain reductions in severity of powdery mildews on several hosts recorded after rain or irrigation (Yarwood, 1978). Triazole fungicides, effective pea powdery mildew control agents (Kerse *et al.*, 1989; Follas & Welsh, 1989), caused rapid collapse of fungal tissue on leaf surfaces. Early growth of the fungus on both resistant and susceptible plants was similar, but on resistant leaves, development later ceased, suggesting that resistance in the host may be a response to penetration of leaves by the pathogen.

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RECOGNITION OF LENTIL VIRUSES

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INTRODUCTION

In a recent survey of lentil crops a number of virus diseases new to New Zealand (1) were found.

Brief descriptions of the virus disease symptoms are given means of transmission, and possible control methods are outlined.

THE VIRUSES

***Alfalfa Mosaic Virus (AMV)*:** Leaves are small, often curled, the growing point may be distorted, plants may be stunted with some stem die-back. AMV is aphid transmitted from surrounding clover pastures and volunteer legume plants. Yield losses of up to 74 % have been recorded overseas (Kaiser, 1973).

Cucumber Mosaic Virus (CMV): Leaves are often small, mottled, yellow, vein banded, and curled. Plants may be stunted with many basal shoots. CMV is aphid transmitted probably from surrounding weeds and horticultural crops. Yield losses of up to 87 % have been recorded overseas (Kaiser, 1973).

Luteoviruses - Soybean Dwarf Virus (SDV) and Beet Western Yellow Virus (BWYV): Symptoms are similar for both viruses. Leaves, particularly the lower leaves, turn yellow then red. Plants are stunted and stems are red. SDV and BWYV are aphid transmitted from surrounding pastures, weeds, and brassica crops. Yield losses are not documented.

Pea Seed-Borne Mosaic Virus (PSbMV): Leaves develop a slight mottle, twisting and cupping. Plants may be slightly stunted and flowering can be delayed. PSbMV is both seed-borne and aphid transmitted from surrounding pea or lentil crops. Disease incidences of up to 16 % (Goodell & Hampton, 1984) have been recorded overseas.

DISEASE CONTROL

To control PSbMV clean seed lines need to be sown. Control of aphids infesting lentils (e.g. *Aphis fabae*) is important to reduce spread of all the viruses described (AMV, CMV, SDV, BWYV and PSbMV). Crops sown in autumn require chemical protection if aphids are still flying. Systemic insecticides such as 'Disyston' and 'Thimet' can be used. During spring growth (September-December) crops require monitoring for the presence of aphids. If five or more aphids are found on plants at five or more sites than 'Pirimor' or 'Mavrik' sprays can be used for protection.

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A SURVEY OF PEA AND LENTIL VIRUSES IN THE SOUTH ISLAND

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INTRODUCTION

The following viruses have been found in previous surveys of peas: alfalfa mosaic virus (AMV), bean yellow mosaic virus (BYMV), beet western yellows virus (BWYV), cucumber mosaic virus (CMV), pea seed-borne mosaic virus (PSbMV) and soybean dwarf virus (SDV) (Ashby, 1988; Chamberlain, 1954; Crampton & Watts, 1968). In lentils only SDV was recorded (Ashby *et al.*, 1979)).

With the expansion of production of both lentils and peas into new regions, incidence of viruses in peas and lentil crops was surveyed. The influence of previous and adjacent crops on disease incidence and the importance of weeds as a disease reservoir for CMV in lentil crops was assessed.

METHODS

In 1987-88, 74 pea and 25 lentil crops were surveyed in Marlborough and Canterbury (Fletcher *et al.*, 1988). (Crops to be surveyed were selected by MAFQual, seed company and process company staff). Area, cultivar, sowing date, crop use, and cropping history were recorded. Samples of 130 leaves were taken from each paddock, bulked then inoculated onto indicator plants or serologically tested using ELISA. Disease incidence was estimated using a modified survey method (Moran *et al.*, 1985). In 1988-89 three lentil crops in Marlborough were surveyed for viruses and weeds adjacent to the crop were also sampled for viruses especially CMV.

RESULTS AND DISCUSSION

Virus incidence in peas was lower than in previous surveys, 0 - 15 % compared with up to 100 % (Ashby, 1988; Chamberlain, 1954; Crampton & Watts, 1968). No new viruses were recorded. The incidence of BWYV (0 - 11 %) and SDV (0 - 15 %) was greater than expected.

In lentils AMV (0 - 7 %), CMV (0 - 87 %), PSbMV (0 - 7 %), and BWYV (0 - 9 %) were recorded for the first time in New Zealand. Virus incidence was greater in Blenheim (15.8 %) than the other survey locations at Seaview (4.5 %), North and South Canterbury (12.7 %).

Adjacent or previous crops did not influence virus incidence. Weeds were not important as a virus reservoir for lentil crops.

The virus incidence was greater in spring sown crops than in autumn or winter sown crops.

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BREEDING FOR RESISTANCE TO PEA SEED-BORNE MOSAIC VIRUS

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INTRODUCTION

Pea seed-borne mosaic virus (PSbMV) was first detected in New Zealand in 1978 (Fry & Young, 1978). The properties of one common isolate, PSbMV-Pam, have been described (Ovenden & Ashby, 1981; Ashby *et al.*, 1986). No unusual seed symptoms were observed apart from occasional cracking of the seed coat.

During the 1984-85 growing season unusual seed symptoms were observed on both field and garden peas. They were described as 'tennis ball mark', 'skid mark', 'coat split' or 'abnormal seed condition'. An abnormally high percentage of small peas was also recorded. Some consignments with these symptoms were downgraded for export markets. In garden peas some affected pea seeds were smooth and round instead of wrinkled.

METHODS

Inoculation experiments onto differential plant hosts, serological tests, and electron microscopy were used to identify the virus. Seed lines were analysed for disease incidence. Control methods were studies in glasshouse and field trials.

RESULTS AND DISCUSSION

Experiments identified PSbMV-ST strain to be associated with the seed symptoms. Seed symptoms were experimentally reproduced. However, the relationship between symptoms and virus incidence in seed lines was not always consistent.

Emergence and survival of plants grown from affected seed were less than those from non-affected seed in some cultivars. The use of insecticides to control aphid vectors was not effective in controlling seed symptoms. Differential host experiments indicated that plants with the 'sbm sbm' genotype, specifically 'sbm-1'[4] were resistant to PSbMV-ST. A breeding programme to incorporate the 'sbm' gene into DSIR pea cultivars has been initiated because of the repeated presence of the symptoms in 1986, 1987, and 1988 seasons.

RESISTANCE PROGRAMME

F_2 bulk crosses are inoculated with PSbMV and over a period of 5-6 weeks any plants with disease symptoms or testing serologically positive are removed. This process is repeated in the F_3 generation. The remaining seed of resistant plants is bulked and further assessed in the field. It is anticipated that after field trials the first commercial releases will be available in 5-6 years.

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LENTIL MANAGEMENT IN MID CANTERBURY

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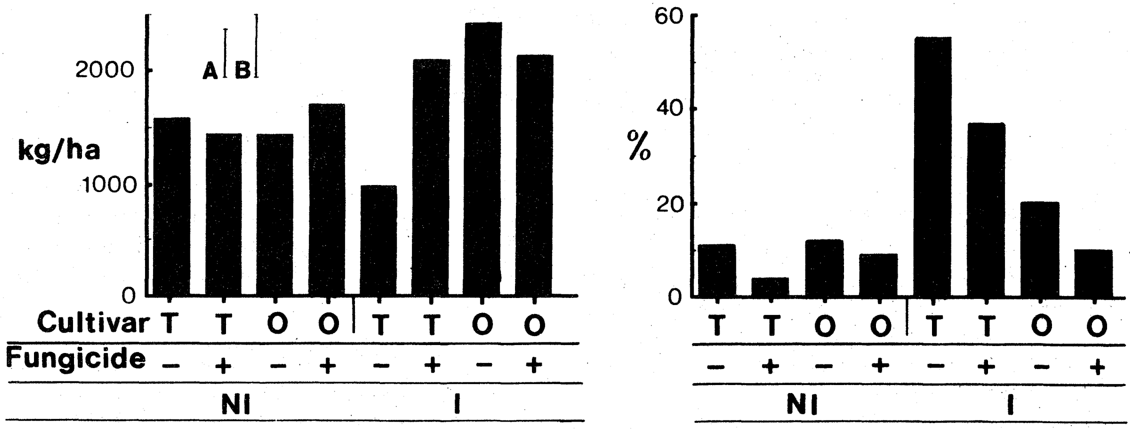
INTRODUCTION

Lentils are a relatively important grain-legume crop in Mid Canterbury. Yield is important, but, as lentils for human consumption are graded on appearance, the seed must have an even colour with no shrivelling or discolouration. Ascochyta blight *(Ascochyta fabae* f.sp. *lentis)* is one of the major causes of downgrading. Irrigation can increase yields, but may enhance the spread of ascochyta blight.

METHODS

Trials were conducted at Winchmore Research Station, on stony Lismore silt loam soil. Cultivars Titore and Olympic were sown on 19 September 1987. These were either border strip irrigated (at 12% gravimetric soil moisture in the top 150 mm), or not irrigated (minimum soil moisture 7%). Either no fungicide was applied or three applications of chlorothalonil (Bravo at 1.5 l/ha.) were made. Measurements included seed yield and disease levels in the seed.

RESULTS AND DISCUSSION



LSD (5%): A = within irrigation comparisons and irrigation interactions, B = other comparisons.

Figure 1a: Lentil seed yield **1b: % seed infected with ascochyta blight**

In Titore, the ascochyta susceptible cultivar, a combination of irrigation and fungicide was necessary to increase yields, but failed to prevent a massive increase in disease. In Olympic, the ascochyta resistant cultivar, yield was increased by irrigation but there was only a small increase in disease level with or without fungicide. Seed infected with the ascochyta blight was discoloured and shrivelled with reduced value.

Unirrigated yields were still reasonable in this relatively dry season. Irrigation should therefore only be applied to cultivars resistant to ascochyta blight.

TRYPSIN INHIBITOR CONTENT OF SOME LOCALLY GROWN PEA CULTIVARS

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INTRODUCTION

Peas *Pisum satium)* like many other legumes contain a range of antinutritive substances which decrease their nutritive value (Savage & Deo, 1989). The trypsin inhibitor content of peas is one-tenth the level found in soya beans *(Glycine max)* and is similar to that in field beans *(Vicia faba)*(Hove & King, 1979; Valdenbouze *et al.*, 1980.) The trypsin inhibitor content depends on pea type; wrinkled-seeded types have less trypsin-inhibitor activity than smooth seeded peas and spring types on average, have less than winter types.

METHODS

Cooking at 100 °C completely destroyed the trypsin inhibitor in all the peas tested (Table 1). This contrasts with the data for lentils (Savage, 1988). Ttrypsin inhibitors in lentils are resistant to normal cooking processes but they are degraded by pressure cooking at 121 °C for 30 minutes.

RESULTS AND DISCUSSION

In general the trypsin inhibitor content of the pea cultivars in this study (Table 1) is comparable with published figures for New Zealand cultivars (Hove & King, 1979; Johns, 1987). They are comparable and low, when compared to the wide range of values in the world literature (Savage, 1988).

While the trypsin inhibitor content of peas is insignificant in human nutrition where they are generally cooked prior to consumption, its effect when fed raw may be significant (Johns, 1987). Johns (1987) showed that there was a close, but non-linear relationship between the trypsin inhibitor content peas and the pancreatic weight of meat chickens fed rations containing 80 % peas.

The addition of methionine to the pea-containing rations markedly improved intake in all cases. This suggests that methionine is directly involved in reducing the effects of the negative growth factors in pancr eatic enzymes which are bound by the trypsin inhibitors in seeds, are particularly rich in the sulphur amino acids, methionine and cystine. Addition of methionine would counteract this effective loss of methionine.

Table 1: Trypsin inhibitor content of raw and cooked peas grown in Canterbury (U/g).

Cultivar	Raw	Cooked
Huka	49.0	0
Pania	26.0	0
Rovar	0.0	0
Whero	71.0	0

As trypsin inhibitors interfere with protein digestion in animals, it is not surprising that in Deo's (1987) work the true digestibility of pea protein was significantly improved by cooking each of the pea varieties.

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NOTES FOR CONTRIBUTORS

POLICY

The Agronomy Society of New Zealand (Inc.) will consider for publication papers in the following categories:

1. Original reports on completed research
2. Summary reports on a long term research programme even if much of the original data has been published elsewhere
3. Progress reports on current research
4. Descriptions of recently developed and tested techniques or equipment
5. Reviews of some aspect of agronomic research and/or practice

The Society especially encourages publication of recently completed work and provides a means of rapid dissemination of this information as the Proceedings is usually published within six months of the Conference.

All authors are expected to interpret their work and to state clearly the purpose for which the results and conclusions should be used.

The Society reserves the right to refer papers to appropriate referees and to accept or reject papers. Accepted papers will be published in the Society's Proceedings whether or not they are presented at the Society's Conference.

MANUSCRIPT

The original and two copies of the final draft on good quality A4 paper are required. Typing should be double spaced on one side of the page. Margins of 3cm wide should be left on both sides and at the top and bottom of the pages.

Output from a wordprocessor is acceptable, provided it is correctly spaced and is of typewriter quality. Also refer to preparation of electronic copy below.

A statement which specifies whether or not the paper has been approved by an editorial panel must accompany the final draft.

LENGTH

Papers, including tables and figures should not exceed six printed pages of the Proceedings. Papers exceeding this length will be subject to special scrutiny and may be abbreviated or rejected. The Proceedings should be used as a guide for estimating length.

FORMAT

In general, formats can be flexible and suit the style of paper but authors reporting the results of research should follow the normally accepted format. Refer to Gandar & Kerr (1980) for further comments on the information which should appear in agronomic papers.

The requirements for the various sections of papers are outlined below, and apply particularly to papers reporting research results. Authors should refer to past papers for examples of acceptable formats. Headings for sections, subsections and sub- subsections will be restricted to one line in length.

Title Titles should not exceed ten words. A good title (i) briefly identifies the subject, (ii) indicates the purpose or main result of the study, and (iii) contains key words. The title must catch the readers' interest as well as describe. For technical articles, the brief description is paramount. The title will need to supply information for the potential reader to make a reliable decision as to whether the paper is of interest.

Abstract Abstracts should not exceed 250 words and should state concisely and clearly the objectives, the results obtained, and main conclusions. An abstract must be completely self explanatory and intelligible in itself, so that readers are able to decide quickly whether they should read further. Since abstracts are likely to be read more often than the associated papers, authors should devote considerable care to their composition.

Key words Additional index words are used to complement those in the title. Important materials, operations, and ideas covered in the article must be given as short phrases or words which are placed immediately after the abstract. They must not duplicate the 'key' words in the title and they should give only the important extra items. To choose additional key words, read through the manuscript for significant words or phrases which characterise the study. Up to five additional key words may be given.

Introduction The aim of the introduction should be to engage the interest of the reader. The introduction should include a short review of the subject to establish the nature of any problems, and the main work previously undertaken to solve them. The objectives of the reported work and/or of the paper itself must be clearly stated. The groups of people expected to use the information should be identified.

Materials and methods Relevant details of chemical, plant or animal materials used, environmental measurements taken, soil type and techniques used should be presented clearly. In many cases these details require little amplification and a tabular form of presentation may suffice. For example, trial designs can be given efficiently in this form. The use of sub-headings is encouraged.

Results The principal results should be presented as concisely as possible. The presentation and use of environmental data is encouraged. Although the 0.01 % or 0.05 % probability levels should be used when presenting statistical analysis of results, higher levels of probability may be used when interpreting data for management purposes provided there is a logical and biological basis for the conclusions (see Douglas & Dyson, 1980; and Maindonald & Cox, 1984).

Discussion and conclusion(s) In the discussion section the author assesses the meaning of the results. Authors should show how the results provide a solution to the problem or satisfy the objectives stated in the introduction, and connect the work of this study with previous work showing how and why they differ or agree. The significance and implications of the work should be explained and possible future developments indicated. Speculation or conjecture that is not clearly supported by data is allowed but must be identified.

Papers must have conclusions either as part of the discussion section or in a separate section. Conclusions should be carefully and unambiguously worded and should be written in a form which is relevant to the intended users of results (e.g., a statistically significant result may be relevant to a scientist, but an adviser is interested in economic significance). For some papers, recommendations in the style of the Ruakura Farmers' Conference Proceedings may be appropriate.

References The accepted style is shown below. Also refer to current or recent Proceedings.

Tables and figures Authors must pay particular attention to tables and figures. They should be kept to a minimum, be clear and concise and kept on separate pages at the end of the submitted manuscript.

Figures must be supplied in their final form as photographic prints reduced to single-column width (8.5cm), or double-column width (17.5cm). Also see 'Electronic copy' below.

Wherever possible, single column-width figures should be used. All numbers and letters must be in a sans serif font. **Care should be taken when preparing the figures so that they can be easily read at the intended final size. Also ensure that all lines and symbols are the correct thickness for their final size.**

ELECTRONIC COPY

Wherever possible electronic copy should be submitted on 5.25 inch floppy (DOS formatted) diskettes in WordPerfect 5.1 format. Text formatting should be kept to a minimun, and sections, subsections and sub-subsections clearly set out.

Tables for electonic copy should be set up in the table mode of WordPerfect 5.1 (Alt-F7 key). Otherwise, use single tabs per column and a hard (keyboard) return at the end of each row in the table. Setting out columns with spaces may require tables to be re-typed.

Electronic copy of figures will need to be in encapsulated postscript format (EPS) or alternatively provided in uniform style as CorelDRAW (.CDR) files or Harvard Graphics (.CHT) files.

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Douglas, J.A. & Dyson, C.B. 1980. Statistical significance in crop fertiliser trials in relation to the profitability of applying fertiliser. *Proceedings of the Agronomy Society of New Zealand* ***10***, 93-96.

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