PRESIDENTIAL ADDRESS

SEED PROTEIN CROPS - WHAT ARE THEIR FUTURE?

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The growing of crops specifically for protein has been investigated by a number of members of this Society. As the question as to the viability of these crops is often raised it would seem to be an opportune time to discuss this question as I see it now and possible developments which may change the present situation. On present evidence, the answer to the above question must be no. However, despite present and future problems I believe there exists a potential for a significant seed protein industry.

Supply and Demand

The stimulus for investigation of these crops came from a world shortage of protein during the early 1970's which drastically increased the price of all forms of protein. The main requirement was (and still is) for a protein supplement for stock feed. For this purpose any New Zealand grown crop must compete with a wide range of animal and vegetable protein sources which fluctuate greatly in price and availability between districts and over time. This makes any accurate long term forecasting of price and demand impossible. At present it is not possible to obtain any long term commitment for supplying vegetable protein at a price that would be economical to produce at known production levels. At the same time we are told that the quality of animal by-products, the main source of protein in stock feeds at present, is declining due to increased efficiency at the freezing works. The inference is that the long term prospect for other forms of protein is encouraging.

At the same time that interest in protein crops increased in New Zealand, lupins as a seed protein crop were gaining publicity in Australia and interest spread to this country. Many farmers attempted to grow the crop with nil, little or wrong information on its requirements and most attempts failed. Those farmers who were reasonably successful and persisted found difficulty in selling what they grew at profitable prices. The result today is very little lupin is grown for seed. Low prices have not helped the situation but initial bad experience by farmers and processors largely through lack of knowledge and experience will make it difficult to renew interest in new developments. A classic example of insufficient evaluation before a new crop is tried on a large scale. Unfortunately the attitude is to condemn the crop rather than seek solutions to the problems.

More recently fababeans (*Vicia faba*) also referred to as tick beans or field beans, have been tried with some success in the South Island. During the last two seasons interest in soyabeans has increased due to the availability of heat treatment equipment which can make the whole bean suitable for use in stock feed without oil extraction.

Present publicity hails soybeans as the crop with the potential to satisfy the demand for seed protein. There is no doubt that soybeans would fit very well with maize in the Waikato but we must remember that the crop is marginally adapted to this region with present cultivars so that in cool seasons in particular, yields may decline markedly. Therefore, until more extensive growing of this crop is undertaken over a range of seasons we should remain cautious.

Peas, being a crop well adapted to most of our environments, must be the main contender as the protein crop for the Southern North Island and South Island. They have a good amino acid balance which compensates in part for their low total protein content.

We therefore have the situation of a range of available crops. It is important some comparative evaluation of these crops be undertaken to clearly define the relative merits of each under a range of environments. Only then can valid decisions be made as to which crops to develop further. This work has not been done adequately and urgently requires attention.

A complicating factor however is that it is difficult to determine what basis to use for comparison as each crop contains varying proportions of protein, carbohydrate, lipids and fibre. For the purposes of this discussion I have assumed protein is the main requirement and this has been used as the basis for comparison.

TABLE 1. Gross margins at a range of yields and prices assuming direct costs of \$260 ha^{-1}.

		Yield (t ha^{-1})			
		2	3	4	5
Price (\$ $tonne^{-1}$)	110	- 40	70	180	290
	130	0	130	260	390
	150	40	190	340	490
	170	80	250	420	590
	190	120	310	500	690

Present Viability

In order to indicate the economic viability of legume crops some gross margins have been prepared (Table 1) based on direct costs at \$260 per hectare which was the approximate cost of growing peas in the Manawatu during the 1977/78 season (Anon.,

TABLE 2. Total seed yield, protein percentage, and protein of a range of grain legumes grown in 1974.

Species	Cultivar	Seed Yield (kg ha^{-1})	Seed Protein Percentage	Protein Yield (kg ha^{-1})
L. angustifolius	(Unicrop)	2980 CD	30.0 C	880
L. albus	(Ultra)	4620 A	36.9 B	1690
L. albus	(Neuland)	3690 ABC	38.1 AB	1390
L. luteus	(Weiko III)	3100 BCD	41.3 A	1280
P. sativum	(Pamaro)	4230 AB	25.0 D	1070
V. faba	(Maris Bead)	2810 C	28.0 C	790
*G. max.**		2800	38.0	1064

* Estimated

1977). Assuming gross margins between $300-400 per hectare for standard crops such as wheat and peas, it is obvious that at 3 tonne per hectare and $150 per tonne, which is the current yield and price expectation in this district for crops such as lupins, they do not compete with crops normally grown on good cropping land. If yield can be raised to 4 tonne per hectare however then they do become competitive.

It must be emphasised again that the amount of information on the yield expectation of these legumes on a paddock scale under good management is extremely limited. Perhaps a case exists for assistance to selected farmers to try new crops such as these in a similar way to the system proposed for horticultural crops.

Future economic viability depends on increasing the yield expectation or price. At this stage, yield sems to be the only factor over which we have much control. A reliable yield over 4 t ha^{-1} is required to ensure a reasonable return especially if prices ease below $150 per tonne.

Criteria for High Seed Protein Yield

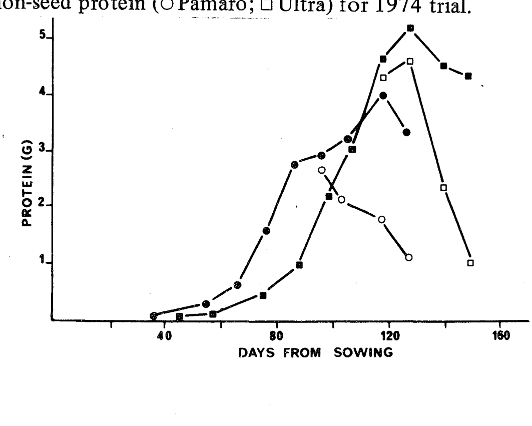
I would like now to give some consideration to the requirements for high seed protein yield which may give some indication of the type of crop we should be looking for. In Table 2 I have presented some unpublished data of a trial I conducted in 1974 in which a range of spring sown legumes were compared at two sowing dates. Data is for the early (13 August) sowing date and I have included estimated figures for soybean as a comparison. As the work was done on small plots, the yields are probably over-estimated but the relativity between crops should be valid. It should be noted that *L. angustifolius* and fababeans were affected by foliage diseases late in their growth which may have reduced their yield.

It is apparent that seed yield is not a good indicator of protein yield. The relatively high protein content of *L. albus* and *L. luteus* give these species an advantage over peas and fababeans and enables them to yield protein at a similar level to soybean. Unfortunately comparisons between lupin and other crops are often made using *L. angustifolius*. In Canterbury, Hill *et al.*, (1977) ranked the crops in a similar order to the above experiment.

It would be helpful to know the reason for the differences in protein yield. If we knew this, we could work more efficiently at increasing protein yield. Sinclair and de Wit (1975, 1976) have suggested that an important source of nitrogen in high protein seed is the reserve present in non-seed plant components. During rapid seed growth nitrogen is withdrawn from leaf and other tissues to compensate for the insufficient supply from the nodules and soil. Eventually, due to protein removal from the leaf, photosynthetic capability is reduced to such an extent that assimilation of carbon and consequently nitrogen is reduced forcing increased demand on plant nitrogen reserves thus causing a "self destruct" sequence. This assumption was tested in a simple model for soybeans. Yields seemed to be limited by length rather than rate of seed development. Duration of seed development can be extended by maintaining nitrogen assimilation at a high rate thereby minimising the decline in leaf area or by ensuring a high reserve of nitrogen in the plant by delaying the rapid seed development phase. The markedly indeterminate plant by producing vegetative growth (especially leaf) and reproductive sites concurrently, can do both these things.

In Figure 1, the accumulation of total and non-seed nitrogen for peas and *L. albus* (Ultra) in the trial previously mentioned is presented. Although it was later entering its rapid accumulation phase, *L. albus* accumulated more nitrogen before the rapid decline in non-seed nitrogen associated with rapid seed growth. Little additional nitrogen was fixed after this point. Non-seed nitrogen declined to similar levels in both crops so that *L. albus* had more nitrogen available for seed growth which probably was the basis for the higher protein yield. The slower rate of mobilisation of nitrogen in the pea may have been the reason for the greater amount of nitrogen

Figure 1. Trends of total protein (● Pamaro; ■ Ultra) and non-seed protein (○ Pamaro; □ Ultra) for 1974 trial.



fixed once seed growth started as "self-destruction" would have occurred at a slower rate enabling more photosynthate supply to the nodules over this period. This compensated to some extent for the low total nitrogen supply at early seed development.

The long growth period and marked indeterminate growth habit of *L. albus* (and *L. luteus*) is thus probably an advantage for high protein yield provided of course the season is long enough for this advantage to be expressed. When late sown or when onset of dry conditions occurs early in growth lupin protein potential may not be realised. The results presented in Table 3 are from a trial sown in September 1977 followed by a dry summer and in this case peas and most lupins had similar protein yields. The cultivar Kali was superior to Ultra because it flowered earlier and had an earlier high rate of growth.

TABLE 3. Protein and seed yield of grain legumes grown in 1977 (kg ha^{-1}).

Species	cv	Protein Yield	Seed Yield
L. angustifolius	Unicrop	1070 A	3690 A
L. albus	Ultra	775 B	2100 C
	Kali	1086 A	2936 B
L. luteus	Weiko III	968 A	2343 BC
P. sativum	Rovar	1086 A	4345 A
	Huka	1005 A	4020 A

Work on a wide range of grain legumes has shown the Sinclair and de Wit (1976) concept applies generally so probably any species of grain legume has similar potential for protein yield provided the basic requirement of a delayed onset of rapid mobilisation of nitrogen is met. An indeterminate growth habit would seem to be desirable. Where leaf is produced at the same time as new flowers and pods, nitrogen fixation can be maintained which lowers uptake of reserve nitrogen by the fruits (Eaglesham *et al.*, 1977) thus extending the period before onset of senescence. This type of habit is also able to fully utilise the available growing period provided other limitations of self-shading, disease etc. do not negate this advantage.

If this hypothesis is correct, we must start to question the use of determinate types of cultivars for seed protein production and the normal practice of spring sowing especially in dry districts. It has been clearly demonstrated that irrigation can substantially increase seed yield (Stoker, 1976) but in most situations it may be better to sow earlier so that flowering will occur early during the favourable spring period and allow the rapid nitrogen accumulation phase to occur over the available growth period as is the practice in Australia. I believe many of the failures in lupin crops are due to sowing too late. Thus, even under reasonably favourable North Island conditions protein yield should be maximised by late autumn sowing.

Autumn sowing has the advantage that the sensitive flowering and pod-set stage occurs at the beginning of the favourable and reliable climatic conditions so the critical build-up of vegetative reserves and yield potential in terms of pod numbers can continue for the maximum time available.

However as all grain legumes are susceptible to waterlogged soils, autumn sowing could only be carried out on free draining soils. In the North Island this would mean that the crop could be grown on soils not normally cropped e.g. coastal sands and pumice soils, thus avoiding direct competition with some high return crops such as wheat. The crop would therefore become economically viable through the increased yield potential of the autumn sowing on land with comparatively low gross margin expectations.

Lupins with their deep root system and general adaptability to sandy soils are likely to be suited to this system. Preliminary trials with autumn/winter sowing on coastal sand and alluvial silt soils (Withers, unpublished data) show yields of 4.5 - 5 t ha^{-1} should be possible. *L. albus* seems to be most suitable although they are very sensitive to waterlogged conditions. *L. angustifolius* has shown susceptibility to disease in this situation. Fababeans are probably less suited to the sandy soils and could have a place on heavier soils.

It is probable that the four main crops – soybean, lupins, peas and fababeans have sufficient differences in their characteristics and requirements that each could find its own niche in New Zealand Agriculture. We need better definition of the relevant requirements of each crop to determine the extent of each niche in competition with each other and with other crops.

Requirements for the Future

I believe that the development of legume seed crops other than peas is at a crossroads. A larger commitment on research than at present needs to be made for a relatively short period of time to resolve some of the apparent limitations so that a clearer picture of the future can be gained.

Some aspects requiring attention are:–

1. An evaluation of the whole range of potential crops over a number of environments to provide good data on the potential environments and yield.
2. Closer investigation into outlets for seed legume other than for stock feed. Lupins in particular with their high protein level and lack of undesirable components would be suitable for more sophisticated uses. They are used for example in pet foods and as meat extenders overseas. The relatively high oil content (5-10%) makes extrusion difficult but initial work at Massey using special types of fungus have produced a bland textured product which could have some uses as an edible product. An effort in product development could thus be worthwhile.
   Associated with this would be a requirement for dehulling lupin as the fibrous seed coat contains little protein and is a major limitation to poultry, human and other uses. Dehulling lupin raises the protein level to approximately 51, 41 and 37% for *L. luteus*, *L. albus* and *L. angustifolius* respectively (Withers *et al.*, 1975). There has been insufficient attention paid to the feasibility of doing this. For example, if *L. luteus* were to be purchased at say $200 per tonne and dehulled at a loss of 20% in weight at a cost of $30 per tonne, the end product would have been produced at a cost of $270 per

tonne. The end product would be similar to soybean meal (Gladstones 1970) which is being sold at present at about $430 per tonne and could still be competitive with soybean meal at its lowest price level. Relatively cheap and simple dehulling equipment is, or can be developed (see for example Anon 1978). Perhaps a dehulled product could find an overseas market even as a substitute for pelleted lucerne. In the longer term, selection for low hull content in lupin is required.

3. Lupins and fababeans at present have some disadvantages. Lupins have relatively low disease resistance and *L. albus* tends to develop too slowly and diverts too much energy into stem growth (Withers, unpublished data). Fababeans have problems with pollination, a tendency to lodge and growth inhibitors in the seed coat. Even if development of improved cultivars is not being undertaken in New Zealand, successful development is being undertaken overseas so a continuous evaluation of new cultivars being produced there must be maintained. Provided the overall potential for these crops is present the faults of existing cultivars must not be used as an excuse for not testing this potential.

In summary, for some time now seed protein crops have been talked about and investigated with varying degrees of success. The momentum is slowing down, at what I believe is a critical time as we have now reached a stage of a better understanding of the factors involved and can identify the critical areas for research. A more co-ordinated effort over a wider field for a relatively short period should resolve the problem of viability satisfactorily. The question of co-ordinated research over a range of disciplines and 'task force' type of research teams has been mentioned a lot at this convention. Here we have a problem which would lend itself to this type of approach and I make a plea for this to be done.

Some Wider Implications

If one assumes that because of our static or diminishing population, demand for many of our standard crop products which are largely tied to internal demand will also stabilise, then new crops must assume increasing importance if arable farming is to continue to grow. If this is correct then the priority for new crop development must be raised perhaps at the expense of research into standard crops.

I have been dismayed by the fragmented and unco-ordinated approach to new crop research and development in this country. There is need for a more rational approach to the problem. I would like to propose a working group responsible for this area. A properly constituted group could do much to co-ordinate research and development, the functions of the group might be:–

a) to act as a focal point for the input of new ideas and information;
b) to evaluate proposals, initiate proposals and to establish priorities for future work;
c) to stimulate research into suitable crops and maintain contact with them to ensure all critical aspects are evaluated fully;
d) to ensure that adequate and accurate information is passed on to farmers.

This is a major task but I believe an essential one to ensure full and rapid development of suitable crops and efficient use of resources. The composition of the working group would be critical and must be made up of people actively involved in the area. The commercial sector would have a valuable part to play although it would have to recognise the value of a co-operative approach to the problem at least in the early and middle stages of a project with normal commercial competition coming in once the basic information has been accumulated. Within the non-commercial sector I would like to see one person responsible for the co-ordination of crop development research in conjunction with the working group.

Thus with limited resources available a co-ordinated approach should ensure rapid development of suitable crops with relatively efficient use of the resources available. I believe the grain legume development is a good example of an unco-ordinated approach which may founder for want of input resources into some key areas for a relatively short time.

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