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CURRENT STATUS OF TEMPERATE PULSE CROP IMPROVEMENT: AN ASSESSMENT OF CRITICAL NEEDS

by

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SUMMARY

Food legumes are of relatively minor importance compared to cereals and do not justify a large research resource allocation. Although principally crops of the Third World, a significant proportion of the research is carried out in developed countries. ICARDA and ICRISAT have played a major role in stimulating research on chickpea, lentil and faba bean, but as yet there is no IARC with responsibility for pea. Many advances have been made recently, especially in disease resistance and improved growth habits, but much remains to be done. New techniques for interspecific crossing and tissue culture offer exciting possibilities for the future. In spite of recent advances, impact at the farm level has been minimal. Special attention needs to be given to the constraints of the resource-poor, small-scale farmers of the Third World who constitute the large majority of growers.

1. INTRODUCTION

The temperate pulses are grown on a total area of about 24 million hectare and are found in all continents. Although, globally, food legumes are second in importance only to cereals, they fall well behind in both production and area (table 1). The temperate pulses have a combined production of less than 10% of that of wheat. It is not surprising, therefore, that they have received less research attention, but in consequence yields have lagged.

Temperate pulses have a far greater importance in developing compared with developed countries (table 1). Approximately 98% of the chickpea, 90% of the faba bean and pea and 30% (80% if USSR is excluded) of the pea areas respectively are in developing countries. Only about 0.05% of the land under arable and permanent crops in the USA is sown to temperate pulses.

2. HISTORY OF RESEARCH

Research on the temperate pulses has a long history, especially in Europe. During the period of agricultural revolution in northern Europe in the 18th and 19th centuries, pea and faba bean were widely grown. Many experiments were conducted by farmers and later by scientists. Until the widespread use of chemical nitrogenous fertilizer, much of this early experimentation focused on the agronomy of pulses as "soil-improving" crops within rotations. Although many early genetic studies, including Mendel's, were conducted on pea, and Charles Darwin (1876) described pollination trials on faba bean, systematic plant genetic improvement was initiated in Europe only in the late 19th and early 20th centuries.

Research on pulses in India dates back to the beginning of this century. Howard et al. (1915), described their work at Pusa on chickpea in the early years of the Imperial (now Indian) Agricultural Research Institute from about 1910. Research on lentil probably started a little later in the early 1920s (Nezamuddin, 1970). In Egypt, research on faba bean was started by the Ministry of Agriculture in 1929 (Ibrahim, 1982) with the first cultivar, Rebaya 8, being released in the early 1930s. However in most developing countries research, when it occurred, was generally poorly supported and lacked continuity. It depended heavily on the interests and energies of a few individuals.

This was the situation until the late 1960s and early 1970s when world attention was focused on what was then seen as a major crisis confronting developing countries; protein malnutrition. Pulses were widely regarded as a key element in the fight against this problem and increasingly funds were allocated by national governments and international donors for pulse research. It was during this period that many of the developing country national pulse programmes were established, as were the two main International Agricultural Research Centres concerned with temperate pulses; the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria, with responsibility for lentil, faba bean and kabuli chickpea, and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India with world-wide responsibility for chickpea. These centres have done much to stimulate national research programmes.

The protein deficiency scare was largely fueled by the publication in 1965 of a joint FAO/WHO Expert Group Report giving revised human protein requirements which were considerably larger than the previous standard published by FAO in 1957. The picture again changed in the mid 1970s following the publication of another report (FAO/WHO, 1973) in which estimated human protein requirements were again reduced. This turned attention away from protein deficiency alone, and total protein-calorie deficit became recognized as the major nutritional problem of developing countries. However, by this time pulse research was already well established. The broader nutritional role of pulses and their agronomic advantages within farming systems, became to be regarded as the primary justification for continued research support. There are now indications that the protein pendulum is again swinging back: the estimated human protein requirements were again increased by an FAO/WHO/UNU Expert Consultation which met in 1981 (Scrimshaw, 1986). This may again lead to greater attention on pulses as a source of human dietary protein.

3. WORLD RESEARCH INTEREST

The prominence given to pulses in the late 1960s resulted in a generous research resource allocation compared to most other crops, in relation to the value of production. Although accurate figures are scarce, one study (World Bank, 1981) reported that in 1971, $25.3 million was spent by national programs in developing countries for research on all pulses, representing approximately 2% of their total value. This compared with an allocation of $35.9 million for wheat, $34.7 million for rice, and $29.6 million for maize research representing 0.65%, 0.26% and 0.75% of their gross value respectively.

In spite of the relative importance of faba bean and pea production in developing countries, there is a greater concentration of research in developed countries. Of 405 faba bean abstracts published by CAB in 1983, approximately 75% were from developed countries. The distribution of the FABIS mailing list shows a similar, but smaller, trend (table 2). Within the developing world, by far the largest research interest in faba bean is in Egypt; 10% of the scientists on the FABIS mailing list are Egyptians. A similar situation exists in peas, with an even greater bias toward developed countries.

In the case of lentil, although only half the scientists on the LENS mailing list are from developung countries (table 2), research output is higher. Two-thirds of the 1983 CAB lentil abstracts originated in developing countries with half of these from India. Over 50% of the subscribers to Chickpea Newsletter are from India.

The classification of research into developing and developed countries is, however, somewhat arbitrary and increasingly scientists are coming together to tackle their problems jointly. Formal and informal links have been formed, e.g. through the EEC Common Research Program on Plant Protein Improvement, and through the encouragement and support of a number of international organizations and donors. The IARCs (especially ICARDA and ICRISAT) have been prominent in this role; convening meetings, publishing newsletters and generally providing opportunities for the exchange of germplasm, ideas and information. Unfortunately no IARC has been assigned responsibility for peas, but the Pisum Genetics Association, based at the New York State Agricultural Experiment Station, Geneva, has published a widely distributed annual research newsletter since 1969.

In terms of relative research output on the four pulses, of more than 1½ million references in the CAB data base from 1973 to 1985, 5,963 are on faba bean, 3,549 on pea, 2,433 on chickpea and 665 on lentil.

4. SOME RECENT ADVANCES IN RESEARCH

Clearly it is not possible to give a comprehensive coverage of the numerous research advances of recent years, and many are covered in depth in other papers. Thus only an overview of a few significant highlights are presented here.

a) **Chickpea**

Good progress has been made developing sources of resistance to two major chickpea diseases; ascochyta blight (*Ascochyta rabiei*) and wilt (*Fusarium oxysporum* sp. *ciceri*). The former can devastate crops through much of west Asia, north Africa, south Europe, Pakistan and north-west India. A number of resistance sources have been identified and several countries in the Mediterranean region have released resistant cultivars.

Wilt is important in India, Pakistan, north-west Africa, Spain, Mexico, and the USA. In recent years, ICRISAT has screened over 12,000 germplasm accessions and identified several resistance sources. Using these, and other sources, several high-yielding wilt-resistant cultivars have been bred in different parts of the world.

Substantial advance has been made in developing cold tolerant genotypes for winter sowing in Mediterranean environments. Of more than 2000 lines screened at ICARDA, 38 have been identified having good cold tolerance. Cultivars combining cold tolerance with ascochyta blight resistance can be planted much earlier resulting in large yield increases as a result of better water use, cooler temperatures during pod filling, a longer reproductive period, better stands and nodulation, and less damage from most insects and birds (Hawtin and Singh, 1983). Several countries have now released cultivars for winter planting and it is expected that this will have a substantial impact on chickpea production over the next few years.

Progress has been reported in the development of resistance to the most serious insect pest *Heliothis* spp. Sources of resistance have been identified, notably ICC 506 which has a very acid exudate and a large concentration of polyphenols in the seed (Smithson *et al*., 1985).

In many parts of the world agriculture is becoming mechanized and there is demand for taller chickpea plants which can be more easily harvested mechanically. Excellent genetic sources for increased plant height exist and have been used in several breeding programmes. The cv. Yialousa (ILC 3279) was released in Cyprus in 1984, and is at a pre-release stage in Syria. The tall cvs. Fardon (ILC 72) and Alcazaba (ILC 2555) have been submitted for registration in Spain.

In India a number of lines of research are showing promise, e.g., the development of cultivars which fit into double cropping systems, and advancing the planting date in the Peninsular.

b) **Lentil**

As with chickpea, many improved cultivars have recently been released or are in the final stages of testing. In the Indian sub-continent and Ethiopia, the diseases wilt (Fusarium oxysporum f. sp. lentis) and rust (Uromyces fabae) are major problems. Khare (1980) has reported sources of resistance to wilt, and this, together with rust resistance should help stabilize production. Ascochyta blight (A. lentis) can be serious in many parts of the world, e.g., New Zealand, Canada, Turkey, Iran, and Pakistan. Several lines originating from the Mediterranean region have shown good resistance in Pakistan (Malik, personal communication). In Canada and New Zealand control is through the use of chemical seed treatment to prevent spread, and in Canada it is recommended that lentil should not be planted in areas designated conducive to the disease.

As with chickpea, the cost of hand harvesting lentil is becoming prohibitive. Scientists in several national programmes, especially around the Mediterranean and at ICARDA, are giving major attention to agronomic practices, machinery design and use, and cultivars to alleviate constraints to mechanization. In north America, and some other parts of the world, lentil harvest is already fully mechanized. The crop is generally cut with a swather, dried in windrows and combined with a conventional combine fitted with a "pea bar" on the header equipped with "lifters". This method has proved less successful on the more uneven, stony soils of the Middle East, especially where inadequate moisture or soil fertility have prevented full vegetative development. For this region the design of small-scale cutters and pullers has received attention (Diekmann and Papazian, 1985).

Good progress is also being made in the development of tall, non-lodging genotypes, however several questions remain with respect to their use: there may be greater weed competition, greater loss of water from the soil surface, and reduced ability to intercept solar radiation as a result of lack of early canopy closure. Non-shattering lentil could provide improvement in yield without basic improvement in yield potential; estimates of losses due to shattering have averaged about 15% in the USA. Shattering is the result of either pod drop or pod dehiscence, with the former observed to be more serious (Erskine, 1984). Some small-seeded lentils have pods which remain intact during threshing, a trait which could be useful in the development of indehiscent large-seeded types.

The strongly indeterminate cv. Indianhead has recently been licensed in Canada as a green manure. A low rate of 2,4-D sprayed at first bloom stops growth for three to four week and inhibits seed production. Cool nights in mid-to-late August stimulates growth until the soil freezes. Indianhead will be promoted as a fallow-substitute to help prevent soil erosion, and contribute organic matter and nitrogen to the soil. The value of the nitrogen fixed by Indianhead currently exceeds the cost of the seed.

Lentil of the Indian sub-continent is exclusively microsperma. Photoperiod requirements in that region preclude the growing of macrosperma from latitudes further from the equator, causing a "bottleneck" in the transfer of germplasm to the sub-continent (Erskine and Hawtin, 1983). However, recent introduction of early *macrosperma* cultivars, especially the cv. Precoz (ILL 4605) from Argentina, to Pakistan and India have proved successful and are being widely used by breeders.

c) **Faba bean**

Some substantial advances have been made in recent years in identifying sources of resistance to several major faba bean diseases, notably ascochyta blight (*Ascochyta fabae*), chocolate spot (*Botrytis fabae*) and rust (*Uromyces fabae*). Several of these sources have been identified as a result of the mass-screening of inbred and partially inbred lines, developed in bee-proof pollinating cages. Considerable attention is now being devoted to incorporating these resistance genes in agronomically superior lines, and to developing lines with multiple resistance.

Some success has been reported in identification of resistance to broom rape (*Orobanche crenata*) (Cubero, 1983), a parasitic weed which is devastating in parts of the Mediterranean region. Chemical control of *Orobanche* is also now becoming feasible. Many scientists regard the faba bean as only partially domesticated; it has an indeterminate growth habit, and a large out-crossing percentage. Efforts have been made to radically alter the plant type and breeding system. There are several known sources of determinacy and these have been widely used in several breeding programmes. Lines are being developed which appear able to respond to improved environments with increased yield rather than increased vegetative growth. Attempts to increase the degree of self-pollination are also showing promising results, for example through the development of types which combine the closed flower mutant with autofertility. Such lines would in the long term be much easier to breed than conventional types, although the opportunity to take advantage of heterosis through hybrids or synthetics would be lost.

There have been several interesting leads on the flower-drop problem in recent years. Types with an independent vascular supply to the flowers within a raceme have shown total flower retention after fertilization, with the final yield limited by the plants' capacity to assimilate and translocate carbon (Gates et al., 1983).

d) **Peas**

Downy mildew (Peronospora viciae), leaf and pod spot (Ascochyta pisi) and grey mould (Botrytis cinerea) are the most important foliar diseases in Europe, but they cannot be satisfactorily controlled with fungicides (Davies et al., 1983). In dryer regions such as southern Europe and India, powdery mildew (Erysiphe polygoni, E. pisi) is a major problem. Sources of resistance have been found to many of the major foliar pathogens and progress is being made in increasing levels of resistance in commercial cultivars.

Pea root rot remains the most prevalent and destructive disease of peas in North America and many other parts of the world (Kraft and Roberts, 1970). It is caused by several pathogens, (e.g., Fusarium solani f.sp. pisi, Pythium ultimum, Aphanomyces euteches and Theilaveopsis basicola) either alone or in complex. Aphanomyces is the most serious disease of peas in the USA and although resistance breeding has been conducted for about 50 years, and some tolerance has been found, the disease remains a most serious problem.

In recent years a major advance in pea has been the development of leafless and semi-leafless types (Snoad, 1981). The recessive afilia gene (af) converts the leaflets to tendrils; another (st) reduces the large leafy stipule to a vestigial structure. The afilia gene reduces leaf area by about 25-30%, while standing ability is improved by additional tendrils. This decreases yield loss and facilitates cutting. In addition the plants dry out better and the seeds have less staining. In the UK, where foliar diseases are problematic, the spread of Botrytis grey mould and Sclerotinia white mould has been shown to be less in semi-leafless types than convential types (Davies et al., 1985). Leafless and semi-leafless peas are less sensitive to drought than conventional-leafed types and could be more productive under arid or semi-arid conditions (Davies et al., 1985). However they may be more susceptible to seed bleaching as a result of greater penetration of solar radiation. Several semi-leafless cultivars have now been released and are proving popular with many farmers.

Rogue types in pea, having smaller seeds and narrower, darker green and more pointed, erect leaflets, have been studied for over 70 years (Bateson and Pellew 1915; Matthews 1973). Attempts to eliminate the problem by selection have met with little success. However rogue types in solid stands have good resistance to lodging and a more open canopy which may reduce the incidence of some foliar diseases. The c.v. Progreta is a rogue type that has had a degree of success in the UK because it is less prone to Botrytis grey mould and Sclerotinia white mould.

5. RESEARCH NEEDS AND OPPORTUNITIES

a) Stability

Numerous authors have indicated the need for greater stability of production and there appears a consensus that this is a greater priority than increasing yield potential per se. An analysis of faba bean production in Northern Egypt (Nygaard and Basheer 1982) illustrates this point well.

Although new cultivars and agronomic practices should ensure productivity in poor years, it is also important that they be capable of responding positively in good years and to improved management. Thus, most programs attempt to strike a judicious balance between improving stability, (e.g., through improved pest and disease control) and increasing yield potential, (e.g., through developing more efficient plant types).

b) Adaptation

Much emphasis has been placed on wide adaptation, (e.g., reduced photo-thermoperiod sensitivity and developmental homeostatis) and significant progress has been made. However, in future, greater attention might usefully be given to the development of cultivars which can better exploit the full potential of specific environments

c) Pest and Disease Control

Although there has been very good progress in identifying sources of resistance to many of the major pests and diseases in recent years, there is still an urgent need for further research and to develop cultivars with multiple resistance. Most rapid progress has been made with resistance to foliar fungal pathogens, and special attention is needed to address other problems such as viruses, root diseases, nematodes, Orobanche, and field and storage insect pests. The problems associated with the development of new biotypes, or races of pathogens have received very little attention so far, largely because good resistances sources, in many cases, have been identified only recently. However it is expected that research in this area will increasingly be needed in the future.

In addition to the development of resistant or tolerant cultivars, extra attention is also needed on other aspects of control including agronomic practices, rotations and chemicals. Biological control is an area of considerable promise for many pests, and has been largely unexplored. The solution to many pest and disease problems probably lies in an integrated approach.

d) Weed Control

Weeds remain a major production constraint in many parts of the world, especially on lentil and chickpea. Although herbicides are available and widely used in most developed countries, they have often been found unsatisfactory. In addition to screening new herbicides, research is also needed on other aspects such as application methods, cultural control measures, the effects of pulse genotypes, crop rotations, etc.

e) **Growth habit**

Exciting advances have been made recently in developing plant types with altered growth habits. Whereas many of these offer excellent prospects for substantially increasing or stabilizing yields, or facilitating mechanical harvesting, much work remains to be done. The optimum agronomic practices for growing many of these new types in different environments need to be determined. In many cases the advantages of the new growth habits, (e.g., erect lentil and chickpea) still need to be fully established.

f) **Quality**

The majority of pulses are consumed locally and do not enter international trade. There is still a very incomplete picture of consumer preferences and uses worldwide. Further information is needed in order to ensure that new cultivars meet local and export requirements. Priority should be given to processing quality and colour, size and organoleptic requirements. There is probably relatively little to be gained from improving nutritional quality, (e.g., protein quantity and quality) except for animal feeds. The main human nutritional aspect which warrants attention from breeders is the development of faba bean genotypes which do not contain the factors responsible for favism.

g) **Others**

Many other areas for potential improvement exist, e.g., improved nitrogen fixation, mycorrhizal associations, and stress tolerance. In certain situations research on these may be important, (e.g., on nitrogen fixation when this is shown to be a limiting factor) but overall the potential for significant improvement may be less, at least in the short term, than for many of the higher priority topics listed earlier.

Many problems remain to be tackled, and in recent years a number of new techniques have been, or are being developed, which hold promise for the future improvement of pulse productivity. These include:

1) **Interspecific hybridization:** Many wild Lens, Vicia, Pisum and Cicer species contain traits (e.g., pest and disease resistance) which could profitably be transfered to the cultivated species. Techniques are being developed at many centres which offer promise that, within a few years, at least some such transfers will become possible. However the variability within existing genebanks of cultivated species is still under-exploited and further collection of both wild and cultivated types is required.

2) **Tissue culture:** Techniques in this field are advancing rapidly. A breakthrough in the area of dihaploid production could have very significant consequences for genetic improvement. Other areas such as protoplast selection and the induction of somaclonal variation also offer promise for the future.

3) **Genetic and Breeding Studies:** The use of morphological and isozyme markers to develop linkage maps could facilitate breeding progress. Inheritance studies of many morphological, physiological and resistance characteristics are also needed. Further work on breeding methods is required, especially in faba bean. Good progress is being made in the identification of stable CMS which could lead to the development of hybrid faba bean cultivars. Research on gametocides could also have far reaching consequences in this regard.

4) **Physiological studies:** The interaction between genotype and environment is still incompletely understood. Although significant advances have been made recently, further physiological studies in this area could have

important implications for the development of both wide, and specific adaptation. Another area in which the application of modern physiological research techniques could prove profitable is in the study of the basis of pest and disease resistance.

6. IMPACT OF RESEARCH

In spite of substantial research progress and the release of improved cultivars in many countries, FAO data over recent years have shown average yield increases of less than 1% per year in both the less and more developed regions (table 3). Over the 15-year period between 1966/70 and 1981/83, global mean yields have increased only 8%, 15%, 12.5% and 6.1% for chickpea, lentil, faba bean, and pea, respectively. This contrasts with global wheat yields which increased by over 20% in the 7-year period from 1974/76 to 1981/83. The comparatively disappointing performance of the pulses may be attributed to a number of factors, for example:

- It may still be too early to expect a substantial impact on national yields. The breakthroughs which lead to the dramatic increases in wheat and rice productivity were years, even decades in the making.
- Legumes are regarded by many farmers as low-input crops. In many developing countries they are grown by farmers who can afford few, if any, inputs. In situations where inputs are limited, they are commonly applied to cereals or cash crops, rather than legumes. Chickpea and lentil, in particular, are grown by risk-averse farmers, on the poorest land and in marginal environments. It may simply be unrealistic, under these circumstances, to expect large yield increases.
- Even in many countries where superior cultivars have been released, seed may be unavailable at the farm level. Seed production and distribution systems are often inadequate, as are extension services. It is essential that

resources be allocated to strengthening these if the results of research are to reach the farmers efficiently and effectively.

- Marketing systems are inadequaté in many countries, and pricing is often controlled at levels which do not encourage investment in purchased inputs. In situations where there are no contolled prices, gluts at harvests can depress prices severely. When prices rise later in the year, only those farmers able to store the crop can benefit.
- Technological innovations which may appear highly promising on research stations may be inappropriate at the farm level; farmers may be unwilling to pay the cost or accept the risks of obtaining credit for inputs; the timing of operations might conflict with other activities; there might be taboos against certain innovations; new cultivars might have unacceptable quality characteristics: etc.

The relevance of new practices and cultivars to the actual farmer's situation is a critical issue for research, and one which is often overlooked. In the more technologically advanced countries, there are normally good feedback mechanisms between farmers and scientists; often the scientists are from a farming background and conditions on research stations are similar to those on farmers' fields. Unfortunately, in many less technologically developed countries the situation is different. Often the scientists are from urban backgrounds, or from rich, landowning families, and may not appreciate the constraints faced by the resource-poor small-scale farmers who normally constitute the majority of pulse growers. Their training has generally emphasized high input production techniques, and they are often confined to the research stations under "ideal" conditions bearing little resemblance to the surrounding farmers. It is hardlý surprising therefore, that the results of research are not always adopted, even by farmers who can observe what is going on within the research station fences. Fortunately, this situation is changing and increasingly researchers are making greater efforts to understand the real problems and constraints of the growers. Research methods have been developed to enable scientists to work more closely with the target farming communities through surveys, on-farm research, the involvement of farmers and extension workers in the research, farmer seminars, etc. Nordblom *et al*. (1985) discuss these research approaches in relation to pulse research in west Asia and north Africa.

7. CONCLUSIONS

In spite of the many achievements of the past, pulse research still faces many challenges. Recent developments in areas such as pest and disease resistance and new growth habits, offer ~~existing~~ exciting opportunities as increasingly will some of the new biotechnological techniques. However, for research to make an impact on the majority of pulse growers, the resource-poor farmers of the Third World, extra attention needs to be paid to the particular problems and constraints under which they are working and living.

REFERENCES

Bateson, W. and Pellew, C. (1915). On the genetics of "rogues" among culinary peas (*Pisum sativum* L.). *Journal of Genetics* 5:13-36.

Bernier, C. (1985). Strategies for disease control in faba beans. In *Faba Beans, Kabuli Chickpeas, and Lentils in the 1980s*. 129-136 (Eds M.C. Saxena and S. Varma). Syria:ICARDA.

Cubero, J-I. (1983). Parasitic diseases in *Vicia faba* L. with special reference to broomrape (*Orobanche crenata* Forsk). In *The faba bean*, 493-521 (Ed P.D. Hebblethwaite). UK:Butterworths.

Darwin, C. (1876). *The effects of cross and self-fertilization in the vegetable kingdom*. London:Murray.

Davies, D.R. (1980). Crop structure and yield in *Pisum*. In *Advances in Legume Science*, 637-641 (Eds R.J. Summerfield and A.H. Bunting). London:HMSO.

Davies, D.R., Berry, G.J., Heath, M.C. and Dawkins, T.C.K. (1985). Pea (*Pisum sativum* L.). In *Grain Legume Crops*, 147-198 (Eds R.J. Summerfield and E.H. Roberts). UK:Collins.

Diekmann, J. and Papazian, J. (1985). Mechanization of production of faba beans, chickpeas, and lentils. In *Faba Beans, Kabuli Chickpeas, and Lentils in the 1980s*, 281-288 (Eds M.C. Saxena and S. Varma). Syria:ICARDA.

Erskine, W. (1984). Selection for pod retention and pod indehiscence in lentils. *Euphytica* 34:105-112.

Erskine, W. and Hawtin, G.C. (1983). *Pre-breeding in faba beans and lentils.*

FAO (1957). Report of a FAO Committee on protein requirements. FAO Nutritional Studies, No.16. Rome:FAO.

FAO/WHO (1965). Report of a joint FAO/WHO expert group on protein requirements. FAO Nutritional Meetings Report Series, No. 37. Rome:FAO.

FAO/WHO (1973). Report of a joint FAO/WHO *ad hoc* expert committee on energy and protein requirements. FAO Nutritional Meetings Report Series, No.52. Rome:FAO.

Gates, P., Smith, M.L. and Boulter, D. (1983). Reproductive physiology of *Vicia faba* L. In *The faba bean*, 133-142 (Ed P.D. Hebblethwaite). UK:Butterworths.

Hawtin, G.C. and Singh, K.B. (1984). Prospects and potential of winter sowing of chickpeas in the Mediterranean region. In Ascochyta blight and winter sowing of chickpeas, 7-16 (Eds M.C. Saxena and K.B. Singh). Netherland:Nijhoff/Junk.

Howard, A., Howard, G.L.C. and Khan, A.R. (1915). Some varieties of Indian gram (Cicer arietinum L.). Memo of the Department of Agriculture of India. Botany Series 7:213-235.

Ibrahim, A.A. (1982). The Egyptian national program. In Faba bean improvement, 373-379 (Eds G.C. Hawtin and C. Webb). Netherlands:Nijhoff.

Khare, M.N. (1980). Wilt of lentil. Jabalpur,India:J.N.K.V.University.

Kraft, J.M. and Roberts, D.D. (1970). Resistance in peas to Fusiarium and Pythium root rot. Phytopathology 60:1814-1817.

Mathews, P. (1973). Genetic studies on spontaneous and induced rogues in Pisum sativum. Ph.D. Dissertation. University of East Anglia.

Nezamuddin, S. (1970). Miscellaneous. In Pulse crops of India, 306-324 (Eds P. Kachroo and M. Arif). New Delhi:ICAR.

Nordblom, T.L., Nygaard, D.F. and Salkini, A.B. (1985). Economics in the design, execution and analysis of on-farm trials. In Faba Beans, Kabuli Chickpeas and Lentils in the 1980s, 291-295 (Eds M.C. Saxena and S. Varma). Syria:ICARDA.

Nygaard, D. and Basheer, A.M. (1982). How yield stability can influence farmers' decisions to adopt new technologies: the case of faba bean production in Europe. In Faba bean improvement, 297-308 (Eds G.C. Hawtin and C. Webb). Netherlands:Nijhoff.

Scrimshaw, N.S. (1986). Problems in the assessment of human nutritional needs. In Dry area agriculture, food science and human nutrition, 34-54. UK:Pergamon.

Snoad, B. (1981). The origin and development of a programme to breed leafless dried peas. In Vicia faba: physiology and breeding, 163-176 (Ed R. Thompson). Netherlands:Nijhoff.

Smithson, J.B., Thompson, J.A. and Summerfield, R.J. (1985). Chickpea. In Grain Legume Crops, 312-390 (Eds R.J. Summerfield and E.H. Roberts). UK:Collins.

World Bank (1981). Agricultural Research. Sector Policy Paper. Washington, D.C.:World Bank.

TABLE 1

Relative importance of pulses in different regions
(Based on FAO 1983 data)

REGION	Total Pulse Area[1] as % of total arable area	Total Pulse Area[1] as % of total cereal area	Temperate Pulse Area[2] as % of total arable area	Temperate Pulse Area[2] as % of total wheat area	Temperate Pulse Area[2] as % of total pulse area
Africa	6.8	17.5	1.0	22.9	14.4
N. & C. America	1.4	3.9	0.2	1.2	13.2
S. America	3.7	14.1	0.3	4.6	8.7
Asia	7.4	10.9	3.2	17.5	42.5
Europe	1.9	3.8	0.6	3.3	33.9
Oceania	0.8	2.1	0.3	1.1	33.3
USSR	2.7	5.4	2.2	10.1	82.2
Developed	1.5	3.4	1.0	4.8	63.0
Developing	6.8	12.8	2.1	17.1	31.1
WORLD	4.4	9.0	1.6	10.1	36.2

1 all pulses, excluding soya bean and groundnut

2 chickpea, faba bean, pea and lentil

3 including area under permanent crops

TABLE 2

Research newsletter subscribers from developing countries

	FABIS Newsletter	Chickpea Newsletter	LENS Newsletter
Total No. of subscribers	757	974	424
Total No. of countries	71	71	48
Percentage of subscribers from developing countries	63%	87%	52%

TABLE 3

Average yields in different regions, 1974/76 and 1981/83 (kg/ha)

REGION	Chickpea 74/76	Chickpea 81/83	Lentil 75/76	Lentil 81/83	Faba bean 74/76	Faba bean 81/83	Pea 74/76	Pea 81/83
Africa	633	669	681	628	1199	1325	697	745
N. & C. America	951	1076	1083	1078	676	1134	1626	1988
South America	552	498	662	525	506	519	757	710
Asia	609	645	582	676	1066	1177	1030	1263
Europe	582	584	730	639	1254	1384	1940	2579
Oceania	---	---	---	---	635	538	1826	1644
USSR	---	---	529	704	---	---	1457	1078
Developed	593	600	766	878	1250	1346	1493	1203
Developing	616	652	597	667	1045	1166	967	1142
WORLD	616	652	613	691	1070	1184	1273	1182