ICARDA/IFPRI LEGUME STUDY

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ICARDA/IFPRI LEGUME STUDY
SUMMARY AND RECOMMENDATIONS

SUMMARY

1. Introduction: This report is ICARDA's response to two recommendations from its Second External Programme Review report i.e.

   i. that ICARDA undertake an analysis of existing evidence on the value of legumes in production systems in the region with respect to both their contribution to soil fertility under stressful conditions, and the possibilities for expansion; in their use as livestock feed; and

   ii. that ICARDA embark on an in-depth assessment on the potential pay-off of further investment in the improvement of lentil (taking into account the contribution to human nutrition, foreign trade, and the sustainability of production systems in the region) in order to determine the appropriate allocation of its resources.

This task has been undertaken as a joint project with the International Food Policy Research Institute (IFPRI) by Peter Oram, Research Fellow Emeritus there, and Abderrezak Belaid, Agricultural Economist, of Algeria, Consultant to ICARDA.

In approaching this assignment both members of the team felt from the start that it would be a mistake to look at the lentil crop in isolation or indeed merely at the technical problems of the food legumes in general as a means of implementing the recommendations of the External Programme Review report. Agriculture in the ICARDA region is in an extremely dynamic phase reflecting wider patterns of social change and urbanisation, and traditional systems of land use in rainfed areas are in a state of flux. It is in this context of technological, social, and economic change that the future significance of the legumes must be viewed, and their potential contribution to food and feed supply, farm incomes, soil fertility, the development of sustainable farming systems, and national economic development, systematically assessed. A broad assessment of the role of legumes is essential, since a simplistic view based merely on their current contribution to agricultural GDP might suggest a low priority to a continuing strong research effort.

2. The global importance of the cool season legumes

The West Asian and North African region (WANA) in which ICARDA is the only International Agricultural Research Centre, is the centre of diversity of three of the five tribes of the family leguminoseae, from which all cultivated food legumes originate. These three tribes (Viceae, Cicereae, and Genisteae) contain all of the cool season food legumes (Chickpea, Faba beans, Lentils, and Peas), as well as a majority of the most widely cultivated forage and pasture legumes, and their wild relatives.

The four food legumes native to the WANA region have spread over time to most ecological regions of the world except the lowland humid and semi-arid tropics, and currently represent 40 per cent of total world pulse area and 53 per cent of world pulse production. Sixty eight per cent of their area and fifty-five per cent of their production originates in developing countries, and in addition to the WANA region (including Pakistan) they are the main source of dietary protein in India, as well as being important in China, Burma, Nepal, Bangladesh, Ethiopia, Tanzania, Argentina, Brazil, Colombia, Chile, Mexico, and Peru. They have also become the most widely-grown legumes both for food and feed, in Canada, Western Europe, Eastern Europe and the USSR.

Annual and perennial forage and pasture legumes from the WANA region have also spread widely around the world; Alfalfa is the most widely grown perennial species, and annual species of Medicago have become the corner stone of the wheat-sheep farming system in the Mediterranean climatic ecozones of Australia.

ICARDA has so far done no breeding work on the forage species; but its cultivars of food legumes are now being released to farmers by national programmes in fourteen developing countries (ten of which are in WANA), and five developed countries. Thus its impact is already being felt over a much wider geographical area than West Asia and North Africa. The potential for further spillover from ICARDA's research to other regions is very large, especially if it expands its collaboration with India and China, which together produce one third of total world pulse supply.

3. <u>The nutritional significance of the cool-season food legumes</u>:

Wheat consumption per capita in the WANA region is higher than anywhere in the world except E. Europe and the USSR, and three times the average for developing countries. Wheat provides most of dietary energy and protein but it lacks certain essential amino-acids which food legumes supply. Thus they are important to a nutritionally well balanced diet, especially for lower-income people who can not afford much meat, in addition to providing variety to the menu. In terms of protein production per hectare/day, four of the world's top-ranking crops are food legumes, all being cool-season species, and they are also the cheapest source of protein. Among these crops peas and lentils rank highest in protein digestibility. Except for problems caused by neurotoxins in uncooked faba beans, the cool-season legume species, especially lentils, are little affected by some of the anti-nutritional factors which cause trouble with several other food legumes, and lentils do not require long soaking before cooking.

Animal products, especially meat, are the main alternative sources of nutritionally well-balanced and palatable protein, but they are a much more costly source. It is reported from Algeria that 25 kgs of lentils can be purchased for the price of one kilogramme of meat, in India the ratio is 16:1, while in Turkey a recent survey indicates that protein from meat is six times as costly. In addition food legumes do not raise cholesterol, and store well in situations where the consumers either do not have access to cold storage or cannot afford it.

4. Demand for food legumes

Despite these advantages, some projections of future demand for food legumes in developing countries postulate stagnant and even negative income elasticities of demand for pulses both for human food and for feed. We believe that these conclusions and also other evidence of low or declining levels of consumption based on regional aggregates, are misleading for a number of reasons e.g.

i. Recent data on food consumption in Algeria, Turkey and Morocco show that p.c. pulse consumption in these countries is rising sharply, whereas p.c. red meat consumption is actually declining in Morocco and Turkey.

ii. p.c. pulse consumption is projected to increase over the next decade by authorities in several countries (Algeria, Morocco, Tunisia, Turkey, Pakistan, China, and India).

iii. Actual levels of total p.c. consumption of pulses listed in the 1979/81 FAO food balance sheets for the countries of the region, as well as their contribution to calorie and protein supply, are well above those implied for the region as a whole by the 1985 TAC priorities paper. This shows lentils as contributing less than 0.9% of dietary protein in WANA. This is the case for only 2 countries. For seven other countries the range is from 2.8 to 8.8 percent.

iv. Important differences exist within countries in levels of consumption of various components of the diet, between urban and rural areas, between different ecological regions, and among different income groups, which are masked by aggregated regional data, but which are clear from food consumption surveys and other national sources.

v. Projections of world and regional production, consumption, and trade in pulses made by the World Bank's Commodities Division for the 1980's have growthrates of demand and supply for pulses to 1990 both for food and feed, which are higher than those indicated by FAO's AT 2000 study. Yet the Bank's projections have already been surpassed by 1987, especially for lentils. For W. Asia p.c. pulse consumption was projected to be 6.1 kg by 1990: it reached 6.6 kg p.c. in 1987. Demand for feed is expand at 5.3% p.a. even faster than that for food.

vi. Imports of food legumes to WANA are rising rapidly, again with lentils in the lead.

vii. Supply and demand for food legumes in WANA are very price elastic.

viii. Pulse area in WANA has increased by 38 per cent between 1979-81 and 1986-88, and is now 13 per cent of cereal area, compared to 8 per cent cited by the EPR (1989).

From this evidence we conclude that both total and <u>per capita</u> consumption of legumes is rising and that rather than a demand constraint there is a supply bottleneck in most WANA countries, which will lead to increasing imports if it cannot be alleviated. In gross terms the region is marginally self-sufficient, but this is an illusion created by the huge export surplus generated by the successful government led drive to increase legume production in Turkey, which naturally sells to the highest international bidder. Food legume imports cost other WANA countries $ 230 million per annum in 1980-1987. It is also an illusion to assume that because several WANA countries have oil reserves the region is not in need of research to improve supplies of vegetable protein. Not only are four countries classified as among the world's poorest by the World Bank, but food consumption surveys in Algeria, Morocco, Tunisia and Turkey show that except among higher income groups in towns meat consumption is very low (averaging only 3 1/2kgs per capita per annum in rural areas of Turkey) whereas food legume consumption is two to three times as high. Thus the poorest countries, the urban poor, rural people, and farm families will suffer most from a pulse shortage.

5. <u>Trade in cool-season legumes</u>

Eight to ten per cent of world pulse production is traded, and the cool-season species represent half of this total, valued at about US $ 780 million for 1984-86. Their order of importance is peas, lentils, chickpeas, and faba beans. Lentils and chickpeas from WANA each comprise about 62 per cent of all world exports in value terms, and 43 and 47 per cent respectively of world imports. Faba beans represent about 15 per cent of imports and exports, and peas 4 per cent of imports but a negligible share of exports. The World Bank's projections indicate that there is an expanding market for pulse exports from developing countries, especially for feed, and the Turkish success with lentils and chickpeas shows that WANA countries can compete in terms of supply, price and quality. These opportunities, and related analysis of market requirements, for feed as well as food, merit careful study by ICARDA. Improvement of quality, and control of storage pests are particularly important.

6. The importance of the cool-season legumes in West Asia and North Africa

Among the cool season food legumes which provide the bulk of pulse supply in the WANA region, Chickpea occupies first place overall, followed by Lentil, Faba Bean, and Peas, in that order. However the importance of different species varies considerably among countries of the region. In North Africa Faba Bean ranks first in all countries, but in West Asia it is only third in importance, chickpea being the first crop in Pakistan, Iraq, and Iran and lentil in Syria, Jordan, and Turkey. Lentils and chickpeas from Turkey are the key pulse export crops of the region.

Each species tends to have an ecological niche. Lentil is pre-eminent in the lower rainfall (250-400 mm) and in the higher altitude zones, because of its greater drought and cold tolerance, but this also tends to lower its yields and shorten its stature, making it difficult to harvest mechanically. Chickpea is grown in somewhat more favourable rainfall environments (300-500 mm) but is not so tolerant of low temperatures, although it has been shown that winter instead of spring sowing could greatly increase yields. It is also susceptible to a major disease, *Ascochyta rabiei*, which can devastate the crop. Thus its yield variability is high, and research is being focused on developing cold-tolerant, disease resistant varieties. Faba Bean is grown higher up the rainfall spectrum (400-600 mm) or under irrigation. It is prone to attack by a parasitic weed *Orobanche*, which can not only cause serious immediate yield loss, but can pollute the soil for years.

Peas are also grown in intermediate to higher rainfall zones in areas with a more temperate climate. At present they are of relatively small importance, but have a potential for feed as well as food use.

Thus each species suits a certain consumer preference, each has a special environmental niche, and each has its own set of production constraints. Therefore it is wrong to assume that by reducing support to research on one species, another will expand to fill its place, there may then be either a demand or a supply constraint preventing this, and the country concerned may have to fill the gap created in the preferred commodity by imports.

7. Sources of growth of legume production in WANA

Despite rising demand, production performance in WANA has lagged in several important consuming countries; growth having been maintained principally by expanding the area under food legumes rather than by increasing productivity. The report identifies a number of reasons for this, including poorly financed, organized, and staffed national research systems, limited allocations of research resources to food legumes, the intractable nature of some of the technical and biological constraints impeding yield improvement and the high costs of production (especially in the case of lentils); weak extension services and unsatisfactory arrangements for seed multiplication and distribution of those improved varieties that have been released. Long time lags of as much as ten years between development of a new cultivar and its release by national systems to farmers have been reported. Economic problems, including rising labor wages, and price and subsidy policies which favour some other crops with lower labor costs, especially wheat, but provide no price stability to food and forage legumes, have acted as a disincentive to their production.

The report examines price/yield relationships in WANA for food legumes and wheat, and notes that governments in some countries have recently raised pulse prices to a level at which their gross profit margins can exceed those of winter cereals even at current average yields, especially for chickpeas. It is also noted that Turkey can compete with N. American producers in world pulse export markets without price or other subsidies. However Turkish rainfed food and forage legume yields are higher and more stable than those in other WANA countries, even though the WANA regional average is higher than that for developing countries as a whole. A relatively modest improvement in yields and/or a reduction in production costs (especially for lentils) would enable several other countries (Tunisia, Syria, and Morocco) to produce food legumes at international prices. Since the latter are about three times those of imported wheat it would be rational for governments to increase technical support and price incentives to stimulate production of pulses so as to eliminate imports or to generate exports even if this meant some increase in cereal imports. Production of pulses could also be expanded to reduce feed grain imports as is now happening in the EEC. The higher yields being obtained for all four cool-season food legumes in several developed countries, especially for peas and faba beans, indicate considerable scope for improvement. The gaps are smaller for chickpeas and lentils which have received less research effort in developed countries.

Even if there is no increase in demand for legumes for food beyond that resulting from population growth, about another 1.4 million tons will be required by the year 2000 from an additional 1.7 million ha of land to feed the extra 200 million people in the WANA region at the current average p.c. consumption of 6.9 kg, per annum, and assuming yields remain static. The share of cool-season legumes would thus rise from its current 5% of total arable area to 6.6 per cent by the year 2000. Lentils will represent 420,000 tons of this increase, chickpeas 500,000 tons, faba beans 190,000 tons, and 290,000 tons of peas, phaseolus and other pulses. There is also likely to be a big increase in demand for forage legume seed, as well as for land to grow forage crops and perhaps sown legume pastures.

This represents a major challenge to ICARDA and to national research scientists not only in the WANA region, but in other countries producing cool-season food legumes, which will face similar problems. India, for example which imported 266,000 tons of lentils in 1988/89, is aiming to expand production of lentils and chickpeas by 50% and 21% respectively in its seventh 5-year plan. China, 70 per cent of whose food legume production is from cool-season species, is proposing a threefold increase in food legume production raising, annual p.c. consumption from 5.4 kg to 18 kg by the year 2000.

8. Opportunities for increasing food legume output in the WANA region

The report examines the options open to raising the growth of food legume production, in the light of the current dynamic state of agriculture in WANA. It concludes:

i. The options for adding to the net area of rainfed arable land are now extremely limited. Its growth since 1980 has been negligible, and may well become negative, as other sectors compete for land, and irrigated area expands.

ii. The development of yield increasing technology offers one major avenue for improving output of food legumes. However there is no single or simple panacea; each of the four main cool-season species has specific problems requiring research, although there are some common features in which ICARDA could be a source of strength - for example

- the need for improved tillage and seeding practices to provide a good plant population and to facilitate weed control and mechanical harvesting;
- better chemical control of weeds and orobanche;
- reduction of high harvest costs and prevention of harvest and post-harvest losses.

The major problems are addressed individually in the report. It is suggested that a short-term strategy for lentil improvement should focus on cost reduction while the long-term breeding objectives of improving plant structure and reducing shattering of ripe pods are being pursued; whereas in chickpea, breeding for Ascochyta resistance combined with winter hardiness should receive immediate priority.

iii. Important opportunities for expanding legume area as well as increasing net returns per ha, and farm incomes could result from most national programs for work on biological nitrogen fixation and plant physiology under water and other stresses.

The report stresses the need for a systems approach to long term technical monitoring and economic evaluation of returns from the new rotations, starting by in-depth analysis of the progress in Turkey. It is suggested that ICARDA should help other countries develop methodology for characterizing ecological zones where fallow could be reduced, and cooperate with them in testing appropriate cropping systems for those areas. This could take the form of a regional fallow replacement research network.

There are some important countries where the typical WANA one year fallow is not practiced, either because the rainfall is high, much of the land is irrigated, or the system is not traditional. These countries include Egypt, Pakistan, and India. Here raising yields is probably the pre-eminent strategy; although less conventional approaches such as systematic intercropping of pulses with other crops in high rainfall or irrigated areas, introducing forage crops into irrigated rotations or perhaps interplanting food or forage legumes between fruit or nut trees at wide row spacings in rainfed areas could be considered. There seems to be a fairly common presumption that pulses are not well suited to irrigated production - this may need further examination by national researchers, though not directly by ICARDA.

Our review of institutional support to legume production indicates that most national research systems in WANA are inadequately funded, lacking staff with advanced training, and organizationally uncoordinated. Resource allocations to research on legumes are particularly low. Links between research and extension are generally unsatisfactory, and extension services also suffer severe financial, personnel, and management constraints. Availability of improved seeds of food and forage legumes is extremely limited, compared to wheat and industrial crops, seed of which generally receives government subsidies. These institutional constraints compound the technical better characterization of areas where the traditional 2 year rainfed wheat-fallow system could be replaced by continuous cropping of wheat or barley in rotation with feed and/or forage legumes; thus raising the present low rainfed cropping intensities of about 0.60% in WANA. The astonishing Turkish success in this respect, which has turned it into the worlds third largest total legume producer and largest exporter in less than a decade highlights the opportunities and provides valuable pointers as to methodological approaches.

There has also been progress in this respect in recent years in other countries, for example in Morocco, Tunisia, and Syria, but primarily in the milder ecozones of higher rainfall (400-800 mm) where much of the fallow has now been eliminated and replaced by fairly diverse cropping systems. However considerable scope is seen to remain in intermediate and lower rainfall ecozones, and at higher elevations, where the choice of enterprises is more limited. A brief review of the potential suggests that perhaps six million ha of fallow could be replaced by continuous cropping in a wheat or barley/food or forage legume system, with wheat, chickpeas and annual forages in the 350-450 mm zones, and barley, lentils and perhaps sown legume pastures in the 250-350 zones, although with overlaps at the ecological margins.

We believe that these changes will be needed not only to meet rising demand for food legumes; but also to help create integrated land use systems including both cereals and legumes, which will avoid the risks of unsustainability inherent in continuous barley production for livestock, and help to reduce pressures on the overgrazed natural pastures.

This approach should also help to maintain soil fertility without large increases in chemical fertilizer use, because of nitrogen provided by the legumes; as well as increasing water use efficiency by generating more food and feed production from the system per ha, and per unit of time, even if the wheat yield may be slightly reduced compared to that from fallow. ICARDA has a comparative advantage over problems of improving the productivity of food legumes, and diversifying land use to develop financially viable and sustainable farming systems. ICARDA should endeavour to work with national governments to reduce such bottlenecks, through policy research, technical support, and especially through training.

We conclude that ICARDA has a more crucial role to play in supporting food and forage legume research in WANA than is the case with cereals and perhaps even livestock, since the number of national scientists allocated to work on legumes is much less, and work on chickpeas and lentils outside the Region is also more limited. Moreover legume research programmes are generally newer and less well organized, with an exceptionally heavy reliance on ICARDA for germplasm, technical assistance, 'Know-how,' access to laboratory facilities, and training. There are other international and regional research institutions and bilateral agencies working on some aspects of cereal and ruminant livestock production; but with the exception of the outposted chickpea scientists from ICRISAT, no other centre works on lentils, other cool-season food legumes or forage legumes. To reduce ICARDA's capacity to work on these crops by introducing further major cuts in its programme would not only impose economic and social penalties on the countries and people of the region, (and on other developing countries which benefit from ICARDA's legume research), but would cause a major set-back in progress towards the development of more rational and sustainable farming systems in WANA.

RECOMMENDATIONS

As indicated in its statement of objectives. "ICARDA's primary involvement is with rainfed agricultural systems in areas that experience limited and highly variable winter rainfall. In these environments, barley, durum wheat, lentil, chickpea and faba bean (Vicia faba) are among the most important crops, and there is a strong focus on the production of sheep, especially in the drier areas".

In full accordance with these stated objectives and in the light of our evaluation, we recommend the following:

1. The food legume program should not be further deteriorated by the phasing out of work on lentils. This species by itself may not represent a high proportion of global crop area or production, but it fills an important ecological and social niche in WANA. Phasing out the lentil program would be doing a serious dis-service to consumers, especially in poorer countries, lower income urban groups, and rural areas, whose dietary dependence on food legumes is increasing as meat prices rise. It would also leave a considerable and damaging gap in the development of improved cultivars adapted to the cropping patterns of low rainfall and/or high elevation areas, and thus to the evolution of more productive and sustainable rainfed farming systems in the region.

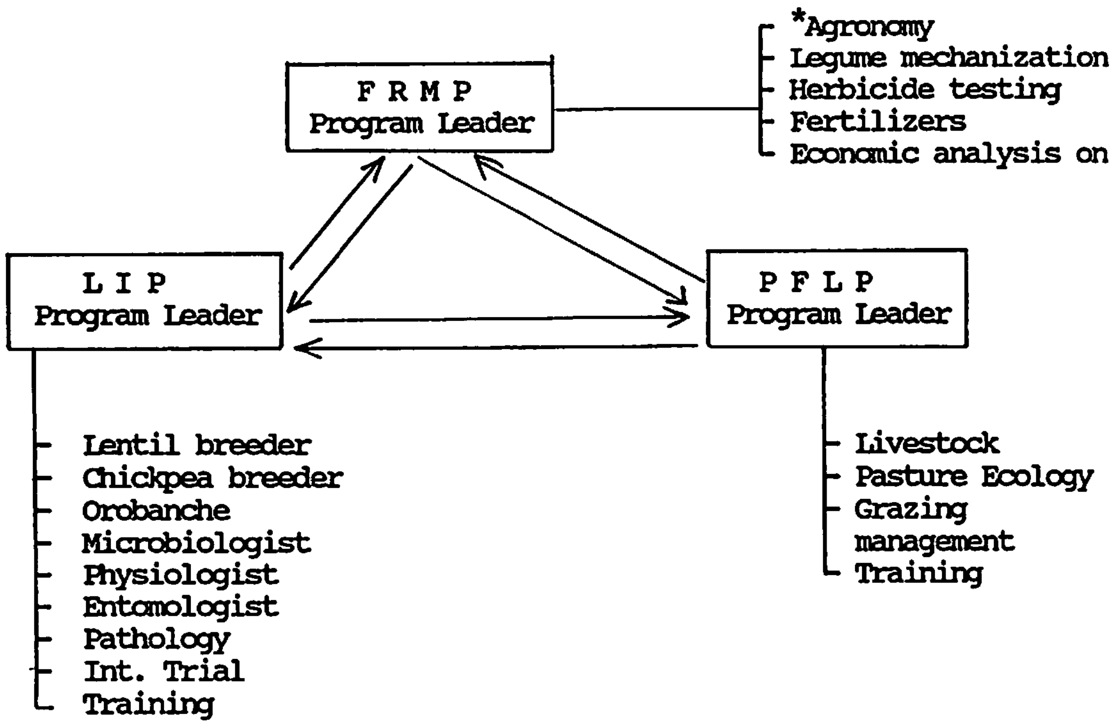
2. This does not imply that a reorganization of ICARDA's research work on legumes might not be beneficial. We believe that there are considerable complementarities in research work on food and forage legumes which might be exploited by some readjustments of research staff responsibilities. We expect such adjustments to lead to economies both in absolute terms and in terms of cost efficiency. More specifically, we recommend that one scientist assigned to each of the entomologist, microbiologist, and physiologist positions should cover both food and forage legumes; that even the "international trial scientist" currently with FLIP, should also cover forage legumes, if need be; that one pathologist should cover both lentils and chickpeas and that the work on Orobanche should be

continued within the legume program at headquarters. Since the program will then be dealing with both food and forage legumes, it would be more appropriate to call it the "Legume Improvement Program, (LIP)" .

3. Additionally, we propose that any legume agronomy work (weed control, fertilizers, mechanization, etc.) should be the responsibility of FRMP. The leaders of both FRMP and LIP should make sure that scientists from both programs actively collaborate in all work related to legumes.

We believe that the implementation of these readjustments will lead to substantial savings due to 1) reductions in scientific and supporting staff assigned to entomology, microbiology and pathology (one scientist assigned in future to each position) and 2) the output of research from LIP will be relevant to both food and forage legumes and their complementarities will have a synergistic impact on livestock production (feed grain and straw from legumes as well as forage legumes improvement and legume pasture). We are conscious of the potential disruption that the implementation of such adjustments may cause in the short term to the work of the staff involved. However, we also believe that this disruption is comparatively less than the social and scientific consequences, at ICARDA and regionally, of closing down the lentil program, leaving a vacuum in food legume improvement other than chickpeas. The diagram below illustrates the proposed adjustments.

We regard this as an option which could be implemented in the medium-term without a major reorganization of ICARDA's existing programs. A more fundamental adjustment aimed at integrating commodity and resource management effort more closely to strengthen farming systems research is discussed in the concluding section of these recommendations.



* These activities concern directly LIP and PFLP. Other major activities of FRMP, not directly related to LIP and PFLP, are not shown here.

4. Discriminatory price policies coupled with, among other things, poorly organized marketing channels play an important disincentive role in farmers' and consumers' behaviour towards food legumes. The market mechanisms, i.e. demand, supply, prices, ultimately influence the type of cropping systems implemented by farmers. Government policy interventions leading to price discriminations may then become a major inhibitor of new technology adoption. Although ICARDA's mission precludes any direct involvement in the policy making process of countries of the region, it does not prevent it from being concerned by the impact of such policies on adoption of new technology related to crops within its mandate. We therefore urge that ICARDA invests some economic effort in the understanding and evaluation of pricing and marketing policies and their effect on food legume production, compared with cereals and other enterprises of importance to rainfed farming.

5. Most countries of the region have launched fallow reduction programs as a means of achieving ambitious food security objectives, and/or for improving their foreign exchange earnings (through exports). Given the importance of the fallow area in the WANA region, it is important that ICARDA evaluates the potential of these programs and their expected effects on the regional economy. This evaluation should include the agroecological characterization of the areas under consideration, and the determination of optimum cropping systems which best exploit the opportunities and role of legumes in the farming systems. It is recommended that serious thought be given by ICARDA to the possibility of establishing a fallow-reduction network in the region.

6. India is the largest lentil producer and consumer in the world. ICARDA, on the other hand, has the world mandate for lentils. The potential benefits of the lentil program at ICARDA would be greatly enhanced if ICARDA could develop a strong cooperative program with India. Consequently, we strongly recommend that, after consultation with the Government of India, an ICARDA lentil breeder be posted there as a a regional scientist in a reciprocal type of arrangement to the one existing for chickpea. This could further strengthen assistance to neighbouring South Asian countries where cool-season food legumes are important, such as Bangladesh, Nepal, and Burma, through the establishment of a regional network.

7. We also recommend the strengthening of ICARDA's cooperation with Latin America, e.g. Chile, Mexico; and with China.

8. The food legume national coordinators represent the link between ICARDA and national programs. They transmit the technical message emanating from ICARDA and provide the centre with the necessary feedback. It is essential that these national coordinators meet together at least once a year, in order to develop, in collaboration with ICARDA, a common and consistent legume research strategy, thus reducing the risks of redundancy. Research problems, achievements, methodologies, work plans, etc.. would

constitute the main subjects of such a meeting. Such a meeting could be held either at ICARDA's headquarters or in the major food legume countries of the region on a rotational basis. Our discussions with staff working on legumes in national systems indicate that this should be given high priority by ICARDA. It could, with profit, include both food and forage legume coordinators.

9. Food legume seed production and distribution systems are poorly organized in the region. The role of an international center such as ICARDA, should not be restricted to the development of high yielding germplasm. It should also help to ensure that the material reaches the farming community. For the breeder and for ICARDA, the ultimate reward is the widespread adoption, by farmers, of the material developed. Such adoption may be seriously jeopardized by a poor seed supply and distribution system which lead to unduly long time lags between the date of release of a variety and the time it reaches the farmer. One consequence of this is the existence of wide gaps between research stations and farmers' yields. Therefore, it is recommended that ICARDA puts more emphasis on assisting national programs to establish and organize more efficient systems of seed production and distribution. ICARDA should attempt to expand donor support to the development of a strong training effort on food legume seed production technology.

10. ICARDA has neither the means nor the mandate to get directly involved in the development and/or the implementation of natinal extension programs. We feel, however, that ICARDA does have an important role to play in training national trainers in order to improve extension efficiency and accelerate technology transfer. The importance of this is emphasized in a recent IDRC study on food legume research in the region. It is therefore recommended that a specific "training of trainers" session, covering cereals, food legumes, forages, livestock, etc., should be instituted as a new 2 or 3 months residential training session. This should be seen as a

might be developed as a cooperative effort with an appropriate overseas institution, supported by special funding.

11. Earlier in this section we recommended restructuring the food and forage legumes programmes to form a single Legume Improvement Programme. We believe that this will be both more cost effective and more productive than maintaining two separate programmes.

However as well as offering advantages in terms of concentration of effort on a narrow front, especially with respect to breeding, a commodity oriented approach has considerable limitations with respect to the evaluation of integrated farming systems involving crops and livestock, on which the future growth and sustainability of rainfed agriculture in the region largely depends. The crop-livestock interrelations are so intricate that only a systems approach is likely to have a real impact on the improvement of productivity of both crops and livestock.

The re-organization of ICARDA's research system overall is beyond the scope of this study. Nevertheless, we feel it is also part of our present assignment to suggest a research framework which, in our view, might best address the future research needs of rainfed environments in WANA, and at the same time achieve economies of scale. Such a framework is indicated schematically below.

The rationale of our suggestions stems from the necessity of establishing an effective <u>interdisciplinary approach</u> including both crops and livestock. Consequently we believe:

i) that research activites that cut across commodity programs, e.g. agronomy, livestock (grazing, straw, forages...), economic analysis, etc. should all be the responsibility of FRMP. The latter might be composed of four main sections:
   - <u>Agronomy</u>: tillage, weed control, fertilizers, agricultural machinery, etc.;
   - <u>Livestock</u>: livestock production and management, grazing

management, feed resources (straw) and quality.

No resources are currently allocated to livestock breeding in ICARDA, and none is proposed; the livestock component is seen as an instrument for testing and evaluating grazing management systems and for forage crop and crop by-production utilization.

- Economic studies: policy analysis, adoption and impact of new technology, farm and other surveys.
- Special studies: Agrometeorology, soil-water relationships, networking and technical coordination.

ii) The commodity programs (LIP and CIP) should concentrate on breeding and laboratory - related activities. It is also suggested that each commodity program should have a position for international trials whereby the scientist in that position is also the interlocutor of the relevant commodity networks.

iii) It does not seem necessary for each program to have its own training unit. We feel that better training services could be provided by consolidating all training resources (staff, equipment, etc) in one department.

We offer these suggestions with diffidence, but in the belief that they will advance ICARDA's mission in the long term. It is, of course, the prerogative of ICARDA's management to assess their merits and the benefits which could result from such organizational changes.

DDG Research

TRAINING

- Cereals
- Legumes
- Production systems

CEREALS

- Breeding
  - D. Wheat
  - B.wheat
  - Barley
- Physiology
- Pathology
- Entomology
- Int. Trials and cereal networks

LEGUMES

- Breeding
  - Lentils
  - Chickpeas
  - Forage legumes
- Pathology
- Entomology
- Microbiology
- Int. Trials and legume networks

FARM RES. MANAGEMENT

- Agronomy
  - Tillage
  - Weed control
  - Fertilizers
  - Water use efficiency
  - Machinery
  - Econ. analysis
- Livestock
  - Livestock prod. & management
  - Feed resources & quality
  - Econ. analysis
- Economic Studies
  - Policy studies
  - Adoption & impact of technology
- Special Studies
  - Agrometeorology
  - Soil water relationships
  - Networks

1. Background to the Study: purpose, goals, and approaches

The charter of the International Centre for Agricultural Research in the Dry Areas (ICARDA) states that "the objects of the Centre are to conduct research and training to increase and stabilize food production in the Region". The latter is specified as "developing countries having a dry, sub-tropical or temperate climate... primarily in the Near East, North Africa and the Mediterranean region."

Specifically ICARDA is to serve as an international centre for research and improvement of barley, lentil and faba bean, a regional centre, in cooperation with other CGIAR Centres, for crops of major importance to the region such as wheat and chickpea, and is to conduct research with the aim of improving systems of cropping, farming and livestock husbandry. Its work on these other crops and farming systems also embraces forage and pasture species, among which legumes play a prominent role.

In interpreting its mandate, ICARDA has held to the principle that it should be concerned primarily with rainfed agriculture in those regions dependant on often low and erratic winter precipitation which in many places comes partly as snow. Although the mandate does not actually exclude work on irrigated farming this focus on rainfed rather than irrigated agriculture has been endorsed by independent review panels including the two quinquennial external programme reviews of ICARDA, and the Technical Advisory Committee (TAC) to the Consultative Group on International Research (CGIAR), which provides financial support to the center.

ICARDA's Second External programme Review made three important recommendations concerning the centre's food legume improvement programme (FLIP) in its January 1988 report to the CGIAR; these were:

i. that ICARDA undertake an analysis of existing evidence on the value of legumes in production systems of the region with respect to both their contribution to soil fertility under stressful conditions, and the possibilities for expansion in their use as livestock feed. The results of this analysis should be used to determine ICARDA's strategy for future research on food and forage legumes;

ii. that work on lentil improvement be continued at the present level for two years and, in addition, that ICARDA immediately embark on an in-depth assessment of the potential pay-off of further investment in the improvement of lentil (taking into account the contribution to human nutrition, foreign trade and the sustainability of production systems in the region) in order to determine the appropriate allocation of its resources;

iii. That ICARDA proceed to implement the CGIAR decision on faba bean as expeditiously as possible. This has since been done by transferring work on this crop to Morocco, with interim staff assistance from outposted ICARDA staff (Breeder and pathologist) until the national programme assumes full responsibility.

In order to meet the first two recommendations the Director General and Board of Trustees of ICARDA decided to appoint outside consultants to review the current and potential role of food legumes in the agriculture of West Asia and North Africa, with particular reference to the significance of lentils, as a means of determining the Centre's future strategy for research on these crops, and their priority in its overall programme of work.

Messrs Abderrezak Belaid, agricultural economist, of Algeria and Peter Oram, Agronomist, Research Fellow Emeritus at IFPRI were asked to undertake this task and to report to the Director General and Board of Trustees by October 1989. The Director of IFPRI Dr. John Mellor, agreed to cooperate with ICARDA in providing support to the study which can be regarded as a joint ICARDA-IFPRI effort.

In approaching this assignment both members of the team felt from the start that it would be a mistake to look at the lentil crop in isolation or indeed merely at the technical problems of the food legumes in general as a means of implementing the recommendations of the External Programme Review report. Agriculture in the ICARDA region is in an extremely dynamic phase reflecting wider patterns of social change and urbanisation, and traditional systems of land use in rainfed areas are in a state of flux. It is in this context of technological, social, and economic change that the future significance of the legumes must be viewed, and their contribution to food supply, feed, soil fertility, farm incomes, and national economic development systematically assessed. It is essential to look at all of these aspects of the role of legumes, since a simplistic view based merely on their current contribution to agricultural GDP might suggest a low priority to a continuing strong research effort.

Taking this broad view does not in any way belittle the need for research on the technology of food legume production, especially with respect to lentils. The pulses as a whole have not received a large share of national or international agricultural research resources anywhere: in the ICARDA region there are more than three scientists working on cereals today for every one on food legumes, and the ratio was considerably wider until recently. Legume yields are low and improving them faces many intractable problems, lentils in particular, which tend to be grown in drier ecozones and at higher elevations, suffer severe biotic stresses. Costs of production are high relative to those of most competing crops which can be more easily weeded chemically and harvested mechanically.

But to quote the late Dr. F.F. Hill's epigram. 'There are many interesting problems requiring research: some of them are important'. It is our task to try and separate the essential from the desirable, and with ICARDA's overall mandate in mind, to do this not only for the individual species of food legumes, but in the light of the opportunity costs of working on those species compared to alternative uses of scarce research resources.

Since ICARDA has a 'global' mandate for lentils as well as devoting substantial resources to work on two other cool-season food legumes, there is also a need to examine how ICARDA might benefit important producing and consuming countries <u>outside</u> its area of main regional responsibility. This requires analysis of the global significance of cool-season food legumes, with special reference to the role of lentils, since other International Centres have 'global' mandates for work on chickpeas and field beans (Phaseolus sp:).

In addition to looking at ICARDA's own food legume programme and its complementarity with other research at the centre-especially the Pasture Forage and Livestock Programme (PFLP) and Farm Resource Management Programme (FRMP), the study pays particular attention to ongoing work in other international programmes within and outside the West Asia - North Africa (WANA) region and especially in national programmes there. The latter are described in more detail in country annexes attached as appendices to the main report.

Both team members have long working experience of agricultural research and development in West Asia and North Africa, and have visited practically every country with a Mediterranean type climate during the course of their duties. However in order to gain an up to date insight into the current problems and status of the legumes in farming systems they jointly visited seven countries of the ICARDA region over an eight week period in May and June 1989.

In addition to extensive travel within the main agricultural areas of those countries and discussions with policy makers, research and extension workers, private entrepreneurs and farmers; surveys of opinion's, farm practices, and constraints were initiated with food legume producers in four countries, Jordan, Syria, Algeria and Morocco.

These surveys were conducted by local research and/or extension staff, based on a questionnaire prepared by the consultants after discussions with ICARDA staff and national scientists, and Dr. Belaid made frequent visits to the countries concerned in July and August to provide guidance. ICARDA helped to cover the costs of travel and local staff assistance from FRMP.

The information on which the conclusions and recommendations of this study are based is thus derived not only from valuable discussions with ICARDA headquarters and regional staff, but also from extensive interviews at many levels in the countries with people who are the clients and beneficiaries of ICARDA's work.

2. The global importance of the cool-season legumes

2.1. Origins and distribution

Although there is a vast range of over 18000 species within the forty tribes of the family leguminoseae, the cultivated food legumes are confined to only five tribes, and the cool-season food legumes to only three, the Vicieae (Lens, Lathyrus, Pisum, and Vicia faba), Cicereae (Cicer), and the Genisteae (Lupinus). The domesticated species of these three tribes all have the West Asia- Mediterranean regions as their centre of diversity, with a history of consumption and cultivation going back to the dawn of civilization. Over the centuries they have spread eastwards to the Indian sub-continent and China, and in the case of Pisum and Vicia faba, Northwards to cooler temperate regions of Europe and more recently to the regions of North and South America, Australia, and Southern Africa with a Mediterranean climate, as well as to some tropical countries at high elevations- for example Ethiopia and Kenya in Sub-Saharan Africa. Tables 1 and 2 show that the four main cool-season species of food legumes represent almost 40 percent of current total world pulse production, only 7 per cent of which actually originates in the countries of West Asia and North Africa. Thus successful research by ICARDA on those species could have benefits applicable to a very much wider geographical area.

Although there are numerous species of cultivated food legumes, they tend to have fairly specific ecological niches. Thus Table 1 shows that 95% of the area of chickpeas, and 90% of that devoted to lentils and Faba beans is concentrated in S. Europe, North Africa, West Asia, China, and the sub-tropical areas of the Indo-Pakistani sub-continent. In the sub-tropics they are grown mainly in the cooler months of the year, with winter rainfall. Except for faba beans they are rarely irrigated. None is located in the humid lowland tropics, although these species are important at higher altitudes within the Tropics, especially in Ethiopia and Mexico. Peas are more oriented to

Table 1. Ecological distribution of the most important food legume species

Ecological Spectrum	Common Name	Specific Name	1987 World Area (1000 ha)	% of World Area	% Production in developing countries
Subtropical winter rainfall	Chickpeas	Cicer arietinum	9.937	14.5	97.5
Subtropical winter rainfall	Lentils	Lens culinaris	3.179	4.7	20.0
Subtropical winter rainfall	Broad beans (Faba beans)	Vicia faba	3.268	4.7	83.6
Subtropical or temperate	Peas	Pisum sativum/arvense	9.770	14.5	19.5
Total coolseason species			26.154	38.4	59.6
Sub-tropical or tropical-summer rainfall species	Haricot beans	Phaseolus Vulgaris[1]	27,208	39.6	83.0
Total sub-tropical/temperate			53,362	77.7	
Tropical	Mung beans	Phaseolus aureus (Green gram)	ND	ND	ND
Tropical (mainly Africa)	Cowpeas	Vigna sinensis	ND	ND	ND
Tropical (mainly Asia)	Pigeon pea	Cajanus cajan	ND	ND	ND
Tropical	Black gram	Phaseolus mungo	ND	ND	ND
Total area of tropical and other species (Lupinus)			15.326	22.3	90.0
		Grand Total[2]	68,688	100.0	64.1

1) This total may include some tropical or other species of Phaseolus or Vigna: the FAO data is not specific on their area or distribution. The figure for the share of production from developing countries is an estimate.
2) In addition groundnuts (Arachis hypogaea) and soya (Glycine max) although grown mainly for oil production and animal feed, are sometimes consumed in a manner similar to pulses.

temperate latitudes, 80% being located in the USSR, China, India, W. Europe, and Australia, with 60% of the world total coming from the USSR.

By contrast Haricot beans (Phaseolus vulgaris) are much more widely distributed, being grown in the lowland tropics as well as at higher altitudes; in the sub-tropics under irrigation or where rainfall is mainly in summer, and in the temperate zone as a summer crop. Approximately 60 percent of their cultivated area is located within the tropics. Cowpeas and mung beans are primarily tropical crops, although also grown in parts of the warm sub-tropics, but not in the winter rainfall sub-tropics- commonly defined as the "Mediterranean" climate.

There is a number of other less important species, but data on their area, yield, production and geographical distribution is not well recorded. They include species of Lathyrus, Lupinus, and Vicia (mainly grown for forage) in the winter rainfall sub-tropics; Lima bean (chiefly grown in the summer rainfall sub-tropics); and many tropical species such as earthnut (Voiandzia subterranea) - not to be confused with groundnut, Hyacinth Bean (Dolichus lablab), winged bean (Psophocarpus tetragonolobus), Tepary Bean (Phaseolus acutifolius) said to be very drought resistant; and at least eight other species.

Most of these are consumed locally by subsistence farmers and have no commercial importance, but some are considered to have wider potential. Winged bean for example, which has the capacity to produce subterranean tubers as well as aerial seed-bearing pods, has been touted as a 'miracle' plant and an institute to propagate it was established in Sri Lanka in the early 1980s. Up-to-date information on this venture could not be obtained.

Thus the food legumes which enter ICARDA's sphere of geographical influence in terms of their ecological affinities are primarily chickpeas, faba beans, and lentils; with peas and haricot beans being of more limited but potential importance. However ICARDA's 'global' mandate extends only to lentils and in a limited sense to faba beans;

since chickpea is ICRISAT's main responsibility - primarily because of the over-riding importance of that crop in India which comprises over 70% of its world area. It is noteworthy, however, that although India also has the world's largest area of lentils (nearly 40% of world total) there is as yet no similar reciprocal arrangement to station an ICARDA staff member in that country. Phaseolus vulgaris is assigned globally to CIAT, since a third of the world area of this species is located in Central and Southern Latin America. No international Agricultural Research Center has a major responsibility for production of peas, which is more heavily concentrated in developed countries than the other major food legumes.

Table 2 shows the distribution of total pulse production by geographical region, and lists the main producing countries in rank order. This highlights three important facts: first that the bulk of pulse production is not located in the humid tropics (or indeed in the tropics at all); second following from this, that world production is shared fairly evenly between developing and developed countries; and third, that over 50% of total world pulse production and consumption is in only three countries - India, the USSR, and China, in that order. Perhaps even more striking is the concentration of almost 70% of production in only three major geographical regions, South Asia, East Asia, and Europe/USSR. There are major differences in the species composition of pulse production among these regions, but any spillover of research done elsewhere on those species (e.g. on chickpeas or lentils at ICARDA) to India or China could provide large economic and social benefits to a majority of the world's low-income people.

It is also most important to note that West Asia and North Africa is also the centre of diversity of many valuable species of forage and pasture legumes including the genera Hedysarium, Lupinus, Lotus, Medicago, Onobrychis, Trifolium, and Vicia. Many of these also have a long history of domestication - Hedysarium coronarium, for example, is known colloqually as 'Sulla' after the Roman dictator with a strawberry birthmark - the colour of its striking inflorescence. Medicago sativa (Alfalfa) appears to be the oldest recorded species grown for fodder.

Table 2. Distribution of Total World Pulse Production for Major Countries by Geographical Region 1986.

Production 000MT	West Asia N. Africa	S.E. Asia	Sub-Saharan Africa	Latin America	N. America	Europe	Oceania
Over 10 mill T		India				U.S.S.R.	
Over 5 mill T		China					
Over 2 mill T				Brazil			
Over 1 mill T	Turkey		Nigeria	Mexico	U.S.A.	France	
500,000 - 1 mill T	Pakistan	Burma	Ethiopia Kenya Uganda		Canada	Denmark	Australia
25,000-500,000 T	Egypt Morocco Iran Syria	Thailand Indonesia Korea DPR	Tanzania Burundi Niger Rwanda	Argentina		Poland Spain Romania Italy	New Zealand
Regional Total: Mill T (1)	3,972	21,912 (2)	2,638	5,007	1,840	15,704	1,065
Region as % world total	7.2	39.7	4.8	9.1	3.3	28.4	1.9

(1) World total: including 'other' developing and developed countries = 55,200 Mill M.T.
(2) Total: India and China = 18,625

As with the food legumes they have spread widely across the world: a most striking recent example being the introduction of annual species of Medicago and Trifolium collected in the Mediterranean and West Asian regions to Australia, as the basis for their adaptation to a wheat/legume/sheep grazing system which has revolutionized the productivity and sustainability of agriculture in the Mediterranean climatic ecozones of that continent. Recently amphicarpic species of Vicia and Lathyrus have been identified (El Moneim 1987, Jones 1988) which may open up new possibilities for forage and grazing in sub-tropical winter rainfall ecozones of West Asia and North Africa.

Unfortunately, despite considerable efforts over the past thirty years, attempts to introduce the Australian system of pasture legumes into the West Asia - North Africa region itself have had no significant success, for reasons which appear to be structural, social, and economic rather than biological.

Even if these problems cannot be overcome, however, considerable scope exists for genetic improvement of the legume species used in more traditional forage production systems within the WANA region, especially those belonging to the tribe Vicieae.

As with the cool-season food legumes (most of which are classified within the same tribe of Vicieae), these mainly annual forage species have been relatively neglected in agricultural research both within and outside the WANA region. There are good reasons to believe that a reinforced breeding effort focused on selected species could have a high pay-off in terms of advances in productivity of both food and forage legumes, while achieving economies of scale through exploiting similarities in their biological, morphological, and reproductive characteristics and agronomic management. Jones (1988) suggests that the only clear distinction between food and forage legumes lies in their mode of utilization in any particular situation, and that applying labels such as food and fodder, and pasture and forage, rigidly to individual species may create a misleading impression of their potential adaptability.

We believe that acceptance of this enlightened viewpoint may be basic to a more cost-effective approach to research on the improvement of legume production in the WANA region.

2.2. The contribution of food legumes to nutrition

Food legumes play an important role in maintaining a nutritionally well balanced diet, both because of their high protein content and relatively high energy component compared to most other foods, and because they are rich in certain essential amino acids - particularly lysine, in which cereals and root crops are deficient. Their calcium iron, and Vitamin B content is also high (Table 3). In addition they are not only free of cholesterol but some species such as chickpea are reported to have a depressing effect on serum cholesterol in human diets (Bressani 1973). Their high fiber content helps to prevent colon cancer, and the nature of their starch content is beneficial to diets of type 2 diabetic patients.

Combining 50-80 grams of food legumes with the cereal in a predominantly cereal based diet (such as is common in rural areas and among lower income groups in WANA), has been shown repeatedly to improve the amount of utilizable protein in the diet, increase weight gain in young people and reduce malnutrition. This is especially important where the cereal protein content and/or quality is not good, as, for example, is the case with wheat. Wheat combined with Phaseolus in a 73/27 protein ratio leads to an increase in quality of almost 50 per cent above wheat alone.

Thus although it has been claimed that modern wheat varieties in India can supply more energy and as much protein per hectare at lower cost than pulses, the quality of the food intake will suffer unless supplemented by food legumes (especially in a vegetarian diet). In terms of protein production per ha/per day Horton (1985), shows that four of the top ranking crops are legumes - dry Faba beans, dry peas, lentils and chickpea (Table 4). Jaffe (1950) ranks twelve species and cultivars of food legumes in terms of true protein digestibility. Peas and lentils are highest, averaging about 93 per cent, followed by

Table 3. Nutritional Status of Common Legumes.

	ENERGY CAL:	PROTEIN GR:	PROTEIN DIGESTI -BILITY	FAT GR	LYSINE %	CYSTINE AND METHIONINE %	CALCIUM Mg	IRON Mg	VITB1 Mg	VITB2 Mg	NIACIN Mg	VITA I.V	AMINO ACID SCORE (1)
LENTILS	340	24.7	92.6	1.3	132	49	79	6.8	0.37	0.22	2.0	50	2.46
CHICKPEAS	360	20.5	90.5	4.8	126	63	150	6.9	0.31	0.15	2.0	50	2.43
PEAS		22.5	90.7	2.5	138	58	NA	NA	NA	NA			2.35
WHITE BEANS	340	22.3	76.8	1.6	132	54	144	7.8	0.65	0.22	2.4	-	2.39
COWPEAS	343	22.8	90.0	1.5	100	NA	74	5.8	1.05	0.21	2.2	30	
FABA BEANS	354	23.4	60.0	1.8	119	44	NA	NA	NA	NA	NA	NA	2.20

1) As % FAO/WHO AMINO-ACID SCORE (Recommended level 2.25).

Table 4. Top Ranking Food Crops in Developing Market Economies in Terms of Dry Matter Production/ha and Edible Energy and Protein Production/ha/day.

Dry Matter Prodn/ha		Energy Prodn/ha/day		Protein Prodn/ha/day	
Crop	T	Crop	MJ	Crop	Kg
Cassava	3.0	Potatoes	216	Cabbages	2.0
Yams	2.4	Yams	182	Dry broad beans	1.6
Potatoes	2.2	Carrots	162	Potatoes	1.4
Sweet potatoes	2.1	Maize	159	Dry peas	1.4
Rice	1.9	Cabbage	156	Eggplants	1.4
Carrots	1.7	Sweet potatoes	152	Wheat	1.3
Cabbages	1.6	Rice	151	Lentils	1.3
Bananas	1.5	Wheat	135	Tomatoes	1.2
Wheat	1.3	Cassava	121	Chickpeas	1.1
Maize	1.3	Eggplants	120	Carrots	1.0

Source: Horton, Douglas E. 1985. Potato Atlas, International Potato Center, Lima, Peru.

chickpeas (90.5%). Phaseolus beans, pigeon peas, and cowpeas are often of considerably lower digestibility, but with wide variability.

Most food legumes store well, provided that they are not infested by Bruchus or other storage pests and are stored at correct moisture content. In this respect they have a major advantage over animal protein sources, especially in low income urban households and in rural areas of developing countries which lack refrigerated storage facilities. Red lentils and chickpeas have a longer shelf life than green lentils, which are prone to discoloration due to a tannin factor. Recent work in Canada suggests that this problem can be eliminated by breeding.

However the nutritional and other benefits of food legumes, should not lead to an uncritical acceptance of their disadvantages. These are both biological and economic. While some species can be consumed fresh in moderate amounts (peas, faba beans, and chickpeas for example), the bulk of consumption has to be cooked, and usually soaked or pre-processed as well, to improve digestibility and to remove anti-nutritional factors which cause excessive flatulence, or which have toxic effects. These include trypsin inhibitors and hemagglutins (which do not seem to be as serious in chickpea or lentil as in beans) goiterogenic factors, cyanogenetic glucosides, tannins, and neurotoxins such as those in seeds of Lathyrus (Lathyrism) and Vicia faba (Favism). According to one estimate, factors contributing to protein digestibility in Phaseolus vulgaris reduce the utilizatable share of protein in human consumption to only 147 kg out of a yield of 1000 kg/ha of the crop.

There is a profuse literature on these various anti-nutritional factors (although the causes of some are still not scientifically well established), but while their existence is generally understood by regular consumers this does not always prevent sickness due to carelessness or insufficient preparation - especially where cooking fuel is in short supply and costly. Three of the main species grown in the ICARDA area, chickpea, lentil, and peas are not as greatly affected by anti-nutritional problems as Phaseolus species, but neurotoxins cause trouble in both Faba beans (Favism) and Lathyrus (Lathyrism), if eaten raw in quantity or inadequately heat treated. Chickpeas and green lentils require soaking for up to 24 hours before cooking, and longer in winter than in summer, followed by cooking for 30 minutes to an hour; red lentils do not need a long soaking period before cooking. These requirements put food legumes at some disadvantage compared to most cereals and many other foods. On the other hand several of the legumes are more versatile in their end uses than cereals, being consumed as fresh vegetables; frozen or canned; used as confectionery like peanuts (chickpeas) as dips (chickpeas and faba beans), as well as being cooked for consumption in various forms such as soup (lentils) or mixed with cereals (rice and lentils).

It is also important to note that food legumes are low in methionine and other sulphur - containing amino - acids, and although cereals are higher in these generally, nutritional deficiencies can occur in some combinations with cereals.

Animal products are the main alternative source of high protein foods with good digestibility and a balanced combination of amino-acids, including the sulphur-based compounds in which legumes are deficient; however, they are not such a good source of energy, cause greater problems with cholesterol build-up than protein of vegetable origin, and are much more expensive per unit of protein and energy, (up to 20 times as much currently reported from Turkey). Food legumes, followed by cereals are generally the lowest cost sources of dietary protein; and cereals, followed by pulses and vegetable oils are the cheapest sources of energy. In terms of their protein quality, digestibility, and relative lack of toxic factors the cool season legumes - especially lentils, appear superior to phaseolus and most other legume species.

Despite its cost disadvantage animal protein has gained over time in its popularity among consumers compared to vegetable protein from pulses. This preference seems partly to be related to a physiological and psychological need for animal protein, which is suppressed by poverty, but is progressively released as incomes rise (high income elasticity of demand). It also appears to be a function of urbanization, as recent studies in Tunisia (Perisse and Kamoun 1988), and Turkey (Gencaga 1985) show. There is probably a relation between urbanization and income growth, since the Turkish study shows that in 1985, 35% of farm families were in the two lowest income groups in that country and that their average per capita meat consumption was only 3.4 kg per year; whereas per capita consumption of meat in cities was about 20 kg per annum, and only 9.5 percent of the salaried population was in the two lowest income deciles. Besides this income differential other factors such as time for food preparation of some legumes and convenience of consumption by office workers, may also be involved.

It will be apparent from this brief review that the nutritional value of food legumes and their contribution to a balanced diet is complex, and that assessments based on simplistic notions such as the gross regional contributions of cereals, legumes, and animal products to proteins and calories in the diet can be misleading as a guide to research priorities, even if notionally indicative of a need for research. For example, many developing countries still have levels of per capita consumption of food legumes which provide a balance with cereals insufficient to ensure a nutritionally adequate diet for low-income people, especially in rural areas (Table 5). Experimental evidence suggests that low legume consumption is not due to a low physiological ceiling on how much a person can absorb. However consumption may be inhibited by the higher unit cost of food legumes due to their lower yields and higher costs of production compared to cereals. The need for long soaking and cooking to reduce or remove the various anti-nutritional factors discussed above may be a further deterrent to increased consumption, especially where convenience is an important consideration.

Supply also fails to match projected demand for food legumes in many countries: comparisons of demand projections to 1980 made by FAO with actual production in that year show that 10 countries of West Asia

Table 5. Per capita food supply (Kg annum) from cereals, legumes, and meat; and their contribution to calories, protein, and fat in the diet: West Asia, N. Africa, and India (1979-81).

Composition of diet (per capita)	Algeria		Egypt		Libya		Morocco		Sudan		Tunisia		Kuwait		Pakistan		Saudi Arabia		Syria		Turkey		Yemen AR		India	
	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of	Total	% of
Total P.C. Food Supply																										
P.C. Cereals Kg/year	192.4		253.4		2078		215.0		142.0		194.1		171.3		168.6		166.0		191.9		210.5		2006		183.3	
Legumes Kg/year	5.7		7.6		10.2		6.1		9.5		7.6		5.9		5.1		3.4		12.2		8.0		12.5		12.8	
Meat Kg/year	11.2		15.3		53.0		15.0		25.5		17.0		79.2		9.6		48.6		22.3		22.3		21.9		1.3	
Total PC Calories Number	2586	100	3175	100	3812	100	2606	100	2314	100	2763	100	3344	100	2180	100	2941	100	3005	100	2997	100	2273	100	2056	100
Cereals	1469	57.0	2032	64.6	1536	40.2	1643	62.5	1197	51.3	15.3	558	1245	37.7	1375	63.1	1314	44.6	15.4	50.3	1608	53.6	1666	53,6	1369	66.6
Legumes	53	2.0	72	2.8	101	2.6	59	2.3	95	4.1	72	2.6	56	1.7	50	2.3	32	1.1	118	3.9	75	2.5	1.7	5.2	123	4.1
Meat	53	2.0	74	156	228	5.9	67	2.5	120	5.2	75	2.7	385	11.5	39	17.9	227	7.7	119	3.9	106	3.5	106	47	13	
Total Protein gr/day	66.2	100	81.1	100	97.9	100	65.6	100	65.1	100	76.2	100	102.0	100	43.1	100	81.5	100	84.5	100	82.7	100	61.2	100	49.7	100
Cereals	44.0	66.4	55.4	68.3	44.4	45.3	48.4	71.5	38.0	58.4	46.3	40.7	31.7	31.7	37.5	66.4	33.4	40.1	43.1	51.0	46.2	55.9	48.1	78.5	38.5	65.4
Legumes	3.5	5.8	5.2	6.4	5.8	5.9	3.7	5.5	5.0	7.4	4.6	4.0	3.6	3.5	2.8	5.0	2.1	2.6	6.6	7.8	4.4	5.3	7.6	12.4	7.1	14.3
Meat	4.2	6.3	6.0	7.4	20.7	21.1	5.7	8.4	10.3	15.8	6.4	8.4	27.7	27.1	2.6	6.4	17.2	21.1	8.1	9.6	8.5	10.2	8.0	13.1	1.0	
Total fat gr/day	56.7	100	65.4	100	134.8	100	50.1	100	72.0	100	69.1	100	102.7	100	43.1	100	79.5	100	80.7	100	71.2	100	46.1	100	32.6	100
Cereals	5.2	9.2	12.8		6.2		6.7		9.1		5.5				6.5		7.9		6.9		6.2		13.3		6.4	
Legumes	.3	.5	.7		3.8		1.3		4.7		0.5		.4		0.6		0.3		2.5		0.9		.8		1.3	
Meat	3.9	6.9	5.4		15.5		4.7		8.4		5.2		29.5		2.6		17.0		9.3		7.7		7.9		1.2	

Source: FAO: Food Balance Sheets 1979-81 Average: FAO Rome 1984
Notes: 1. Cereals, Legumes, and meat are not the only components of food supply, therefore their percentage shares will not amount to 100.

and North Africa as well as India failed to approach the projected level, and in all of those countries the 1980 projected demand has not been matched by domestic supply even by 1988. In seven countries supply has not increased over the 1980 level or has declined by 1988.

These results suggest that there is indeed a need for strong and continuing research, to improve yield per hectare and increase supply, to reduce unit costs to consumers, to raise protein efficiency of pulses, and to reduce factors leading to long preparation time. There is evidence of wide genetic variability both within and between species in the factors affecting quality and digestibility, suggesting that a two pronged approach to breeding both to improve yield and quality may be necessary. If, as can happen, there is a physiological antagonism between improvement in yield and improvement in quality, the former may have to receive priority, especially in countries with large supply deficits.

2.3. Food and feed demand for cool-season legumes

It seems probable that an important factor influencing the external review team's recommendations concerning faba beans and lentils as well as the TAC's endorsement of those recommendations was the evidence then available on income elasticities of demand for food legumes, both in the ICARDA region and more generally.

Estimates of demand for food are generally determined by projecting population and income growth weighted by national income elasticities of demand: the latter vary considerably according to per capita income and the extent to which demand for the various components of the diet is already satisfied. Poor countries, and the poor in all countries tend to spend a higher proportion of their disposable income on food, and because their dietary needs are often not fully met even for basic food staples like cereals, income elasticities of demand for such commodities tend to be relatively high compared to those in richer countries, especially where income distribution is equitable in the latter.

Demand for cereals, root crops, and food legumes is higher in occupations such as farming where heavy manual labor stimulates a physiological need for high-energy foods. This is clear from the food consumption surveys cited above. The nature of foods consumed in rural areas is also different: more unprocessed products; whole grain rather than industrially baked bread, pulses rather than meat; yogurt and sour milk rather than homogenized milk in cartons from large dairy plants, is eaten in rural areas. Thus demand, and even more, the nature of demand can be influenced significantly by a change from a rural to an urban way of life.

It has been estimated in Turkey for example, based on the large food consumption survey referred to in section 2.2. above, that of the three factors which influence changes in food consumption habits, (population growth, changes in incomes, and urbanization), each accounts for about a third of the rapid increase in per capita consumption there of red meat and vegetables. This is not the case for most other commodities, where population growth accounts for almost three quarters of the demand.

As incomes rise, demand for basic staples becomes satisfied and their income elasticities decline, while remaining high for more costly foods such as meat, fruit, vegetable oils and dairy products. At high levels of per capita consumption of a commodity, elasticities may even be negative. Then population growth is the main factor influencing the continued growth of demand.

This point has been reached with respect to cereals especially wheat and wheat products) in most countries of WANA, where per capita consumption now exceeds 200 kg. In Morocco, for example, it has declined overall from 216 kg p.c. in 1970/71 to 210 kg in 1984/85; although increasing in urban communities from 158 to 169 kg p.c. over the same period. In Turkey cereal consumption is over 200 kg. p.c., and income growth is expected to have almost no impact on future demand (Somel 1987; Richards 1984, El Sherbini 1980).

The situation in most other countries of the WANA region is likely to be much the same, since the only ones in which calorie energy did not exceed the FAO Basic Metabolic Rate of 2200 kg/Cal in 1984 were the Sudan, Afghanistan, Yemen Arab Republic and Yemen Democratic Republic, all countries with a GNP per capita which places them among the poorest group. Elsewhere in WANA calorie levels were from 5 to 55% above the calculated need, with a mean of 16 percent. However, in all of the North African countries, plus Iran, Iraq, Syria, Afghanistan and the two Yemens in W. Asia, food production per capita declined between 1975 and 1984 indicating that increased food imports may be required to maintain current levels of energy and protein intake unless the rate of production of high-energy foods can be increased.

Projections of income elasticities of demand for food legumes tend to be approximately the same as those for cereals, or slightly higher (Turkey, Morocco). Somel (1986), however, postulates a negative trend in total demand for pulses especially for feed. His projected 1983-2000 growth rates of demand for cereals and pulses respectively are 3.0 percent and 2.0 percent per annum. Population growth is 2.57% per year.

While population growth, income growth and elasticity of demand, and urbanization, are the main driving forces in raising and changing demand for food; two other influences need to be taken into account in looking at future requirements for food legumes, which are difficult to quantify. These are the impact of inflation, and concerns about the effects of certain foods on health - primarily products of animal origin. The evidence concerning inflation is limited but we were informed by policy-makers in Turkey, Pakistan, Tunisia, and Algeria that inflationary forces and particularly rising prices of animal products, are forcing consumers to depend more on cheaper foods, such as legumes as a source of quality protein. The Turkish food consumption survey lends support to this view. Per capita consumption of pulses has doubled in Turkey between 1974 and 1982; almost tripled in Algeria, and risen nearly 20% in Morocco between 1970/71 and 1984/85. Meat consumption has declined in both Turkey and Morocco-especially red meat.

Concerns about the possible adverse influence of consumption of products of animal origin on high cholesterol, stroke, and coronary heart disease have undoubtedly persuaded consumers in developed high income countries to reduce their intakes of meat, eggs, milk, butter, and cheese. However, it is not clear that this has led to an increase in food legume consumption as an alternative source of protein. This is probably because the problem seems to relate more to fats of animal origin; hence the main substitution has been of vegetable oils for animal fats, both for cooking and for direct consumption e.g. margarine for butter, low fat for full fat milk, synthetic cream, lean cuts of meat and bacon, and a reduced intake of eggs and full - fat cheese. Thus while pulses and fresh vegetables may have been substituted for meat, the main commodities for which demand has increased have probably been vegetable oilseeds.

In terms of equity, the Turkish survey makes the important point that some items of the diet are consumed at approximately similar levels by different income groups, regions within the country, and settlement sizes, whereas others are mainly consumed by higher income and urban families. The latter include red meat, poultry, eggs, and some fruits and vegetables. Foods which are consumed more equitably include bread, cheese, sugar, vegetable oils; potatoes, onions, and tomatoes among vegetables, and pulses. Thus it is argued that to the extent that governments wish to promote social welfare, their support policies with respect to prices, subsidies, or rationing of foods should be targeted to commodities which tend to be consumed by the poor rather than being applied unselectively to all food items.

The other main end-use of food legumes is for animal feed. Grain of several species is fed to livestock as part of concentrate feeds, small-seeded faba beans ('horse beans'), peas, and vetches being among the most common. No reliable data on total consumption for this purpose could be found; the FAO production data on food legumes does not differentiate food and feed. The straw of some food legumes is also fed to animals as forage, although farmer's preferences and opinions as to its value seem to vary quite widely from country to country. Lentil, faba bean and vetch straw are often considered valuable (particularly the former), chickpea less commonly. Because rising demand for animal products is pushing their price up, prices of forage and straw are also rising - in Syria, for example, lentil straw was valued at about 70% of the value of the grain in 1989. In Tunisia some farmers in higher rainfall ecozones are producing forage crops namely for sale, keeping few or no livestock themselves. However, forage legumes grown for hay, and cereal straw (especially barley), also compete with food legume straw so it is probably wise to look on the latter as a useful by-product rather than as a primary source of income. One would also expect demand for grain of food legumes as feed to rise as a consequence of the rising demand for animal products, probably faster than that of their consumption for food. This is happening with barley, but Somel projects a marked decline in demand for feed from pulses to AD 2000 with an implicit income elasticity of - (2.6.).

Classical economic theory lends support to projections of low or even negative demand for cereal products for food in countries where dietary energy intakes are as high as is generally the case in WANA, and this might possibly also reduce demand for pulses. Conversely high income elasticities of demand are generally projected for livestock products due to rising incomes and increasing urbanisation. Despite this conventional wisdom there appear to be forces at work in several important WANA countries and elsewhere, which cast doubt-on the conservative projections cited above.

These include:

i) Rising per caput (not just total) consumption of pulses for food in Turkey, Morocco, Algeria, Syria, Pakistan, and Tunisia which suggests income elasticities of demand higher than those projected in some reports (Table 6).

ii) Low intakes of dietary protein in several WANA countries compared to nutritional requirements - the opposite of the calorie situation. Thus there is more potential demand for pulses, with evidence from Algeria, Turkey, Syria and Morocco that price

Table 6. Per capita consumption food legumes: WANA and other selected developing countries.

COUNTRY	Lentil[1]		Chickpea		Faba bean		Peas		Phaseolus		Groundnut		Other[2]		TOTAL		Kg/percapu per year[3]	
	GRAMS: PER CAPUT PER DAY																	
	1965	1980	1965	1980	1965	1980	1965	1980	1965	1980	1965	1980	1965	1980	1965	1980	1965	1980
Algeria	N	3.7	2.6	4.1	3.6	2.6	0.7	0.6	0.7	4.4	0	0	3.3	N	10.9	15.4	3.9	5.7
Morocco	N	0.6	3.3	2.9	5.1	5.6	2.6	3.3	1.9	0.8	0.2	3	1.3	1.3	14.4	14.5	5.3	5.3
Tunisia	N	0.4	4.7	9.9	6.6	5.4	0	0	0.6	0.7	0	0	0.8	4.4	12.7	20.8	4.6	7.6
Libya	N	0.9	2.9	3.3	1.7	7.1	1.0	1.2	0	1.6	8.8	11.0	1.8	2.9	16.2	28.0	5.9	10.2
Egypt	N	3.2	0	0.6	8.6	10.1	0.1	0.3	0.8	3.6	3.5	1.3	6.8	0.6	19.8	19.7	7.3	7.2
Sudan	N	0	0	0.4	1.8	2.8	0	0	2.0	0.5	1.2	14.2	11.3	8.1	16.3	26.0	6.0	9.5
Iraq	N	N	0	N	4.7	N	7.7	N	3.0	N	0	N	0	0	15.4	N	5.6	N
Jordan	N	N	6.1	N	0	0	0	0	5.7	N	0	0	11.6	N	23.4	N	8.5	N
Lebanon	N	0	0	0	0	0	0	0	0	0	2.6	0	20.7	-	23.3	N	8.5	N
Syria	N	7.4	N	14.1	N	3.3	0	0.2	5.2	2.8	1.6	5.0	12.1	0.6	18.9	33.9	6.9	12.2
Turkey	N	3.6	5.5	6.6	2.6	1.4	0.4	0.4	10.7	8.2	1.6	1.3	7.2	0.3	28.0	21.8	10.2	8.0
Kuwait	N	5.2	0	3.7	0	2.6	0	0	0	2.6	10.0	1.7	-	1.7	10.0	17.5	3.7	6.4
Saudia Arabia	N	2.3	1.2	N	3.0	2.2	0	0	1.2	0.6	0.6	0.4	1.2	2.5	7.2	8.0	2.6	2.9
Yemen Arab Rep	N	N	N	N	N		N	N	N	N	N	N	20.4	N	20.4	34.3	7.4	12.5
Pakistan	N	1.0	N	8.0	0	0	?	?	ND	2.0	ND	0.3	ND	2.8	ND	14.1	N	5.1
India	N	1.4	20.4	14.3	0	0	3.8	1.0	8.1	8.3	1.6	0.8	17.5	9.4	50.4	35.2	18.4	12.8
China	N	N	N	N	N	5.7	N	5.2	N	4.0	N	3.7	N	0	N	18.6	N	6.8
Mexico	N	0.4	6.8	3.5	2.2	2.2	0.3	0.2	48.9	41.5	2.8	3.0	1.1	0.5	64.1	51.3	23.3	18.7
Chile	N	2.0	0.9	1.0	0	0	1.9	2.2	13.2	10.9	0	0.3	0	0	16.3	16.4	5.9	6.0
Peru	N	0.2	0.6	0.3	6.1	3.0	6.3	2.6	10.8	6.5	0.8	0.9	2.9	1.6	27.4	15.1	10.0	5.5
Argentina	N	0.9	0.6	0.3	0	0.4	2.4	0.6	2.0	1.8	0	0.5	0.8	0.2	5.8	4.7	2.1	1.7

SOURCES: F.A.O. Food Balance Sheets 1964-66 and 1979-81.

Notes: 1. No lentil data cited in 1964-66 Food Balance Sheets (N = No data available).
2. Not identifed by FAO.

elasticity of demand is quite high: demand has risen considerably with reductions in consumer prices consequent on increased supply or government intervention in the market through subsidies and/or imports.

iii) Sharp increases in meat prices in several countries of the WANA region, so that meat consumption p.c. has actually fallen. Pulses are as important a source of protein as red meat in Turkey overall, and in rural areas and for low income groups in cities they contribute two to three times as much.

iv) Estimates of feed demand for pulses world-wide, which are quite optimistic, particularly those made by the World Bank commodity division. Comparing the 1970's with the 1980's their report states: "Over the 1970s world pulse production fell, mainly due to better returns from other crops such as cereals and soybeans, the lack of new improved varieties, the absence of support measures in many countries, and bad weather in a number of major producing countries at the end of the decade. The fall in production led to rising prices in many countries and reduced demand, especially by the poorer sections of the population in developing countries. In addition, the higher incomes of some groups and the increased availabilities and relatively lower prices of livestock products in some countries, resulted in a shift in consumption to animal proteins.

In the early 1980s, however, these trends have been reversed. production has risen sharply following increased support to pulse production in a number of countries, while demand for both food and feed has expanded.

"The increased emphasis on raising pulse production stems from a variety of considerations, including shortages and high prices of pulses; the achievement of self-sufficiency and emergence of surplus production of cereals and low prices for these crops on export markets; the opening up of new export markets for some pulses e.g. mung beans from Thailand, and lentils and chickpeas from Turkey); and the high prices of fertilizer, which stimulated interest in pulses as they return nitrogen to the soil. In addition research into new varieties has been stepped up in a number of national and international centres, which along with improved extension services is expected to raise yields. These factors are expected to lead to a substantial increase in output by 1990, assuming normal weather conditions".

As a result the Bank makes the following assumptions for production, consumption and trade of pulses through 1990:

- Output of pulses is projected to grow at 2.5% per annum in developing countries, due to an increase in both area and yields. This is in contrast to the previous decade when production expanded at only 0.2 percent annually. In developed countries a substantial turn-round in production is anticipated from a fall of 2.9% a year in the 1970's to an increase of 3.7% a year in the 1980's. Overall an annual growth of 2.8% in world production is expected, from 41 million tons in 1979-81 to 54 million tons in 1990 (In fact this figure had almost been reached by 1987 when production reached 53.3 million tons. Projected to 1990 at 2.8% compound, production could then reach 58 million tons.).
- Demand is expected to grow by 2.7 percent a year to reach 54 million tons by 1990. Again this is a sharp contrast to the 1970's when total and per capita pulse consumption actually fell. The turn-round is due to projected increases of 2.1% in demand for food and a 5.3% growth in demand for feed through the 1980's - from 7.2 million tons in 1979-81 to 12.2 million tons in 1990. Most of the feed increase will be in developed countries; although India and China may also use more pulses for this purpose.
- Per capita consumption in the developing countries is projected to rise from 7.7 kg in 1979-80 to 7.9 kg in 1990, having fallen from 9.1 kg in 1969-71. This is due largely to an expected decline in relative prices in a number of countries. In the developed countries food intake is expected to stabilize after having fallen steadily in the past, due to increased demand for health foods and improved processed pulses with reduced cooking and preparation time.
- Trade is projected to grow at 3.0% a year worldwide to reach 3.7 million tons by 1990. Much of this is expected to be due to

increased imports of feed pulses by the EEC and Japan, with EEC purchases rising 5.5% a year to reach 1.4 milion tons by 1990. Net EEC imports are projected to reach 0.7 million tons, offering export opportunities to third World countries that can deliver the right product at prices competitive with soya bean meal and other feeds. Consequently developing countries are projected to increase exports substantially, from 1.1 million tons in 1979/81 to 1.9 million tons by 1990, Turkey being the leading exporter.

Developing country imports are projected to increase more slowly at only 1.2% a year in the 1980s, reflecting assumptions of an accelerated growth rate of production in several important countries which were major importers in the 1970's. Pakistan may be an exception, since imports could rise faster due to trade liberalisation there.

In fact world imports have risen faster than projected by the Bank, reaching 3.9 million tons by 1985, (1984/86), a 45 percent increase since 1980 compared to the projected 37 percent increase from 1980-1990. Fifty two percent of these imports were composed of cool-season pulses (Table 7). There has evidently been a faster growth of imports to developed countries than to developing, since the latter have fallen from 51 percent of the world total in 1980 to just over 42 percent in 1985. The percentage increase of 20% in developing country imports between 1980 and 1984-86 has nevertheless been more than double the Bank's expectations. This suggests that the demand for pulses may have been under-estimated by the World Bank as well as by the ICARDA External Review Panel.

It is also indicative that the aggregate regional estimate of per caput consumption of legumes and their contribution to protein supply in the WANA region in the 1985 TAC priorities paper appears to be both too low by 30 to 200 percent in absolute terms, when compared to current consumption levels in most countries of the Region and incorrect in its assumption that per capita consumption will decline (see Tables 5 and 6).

Table 7. World Trade in Cool-season Food Legumes and the Share of the WANA Region.
(1984-86 AVERAGE)

COMMODITY	WORLD EXPORT		REGIONAL SHARE		WORLD IMPORTS		REGIONAL SHARE	
	VOLUME M.T.	VALUE 000 US%	VOL: %	VALUE %	VOLUME M.T.	VALUE 000 US$	VOL %	VALUE %
LENTIL	394,085	187,399	72	62	375,794	197,211	43	43
CHICKPEA	275,206	125,617	76	63	178,336	100,452	63	47
FABA BEAN	386,959	109,107	11	13	277,545	81,551	10	15
PEAS (DRY)	1,362,880	244,019	0.1	0.1	1,203,297	403,366	3	4
TOTAL MEDITERRANEAN AND TEMPERATE PULSES.	2,419,130	666,142	22	31	2,034,972	782,580	17	21
WORLD TRADE ALL PULSES	3,875,755	1,504,426	14	15	3,923,970	1,642,074	13	14
4 CROPS AS % WORLD TRADE	62.4	44.3			51.9	47.6		

Sources: FAO trade yearbook 1987.
World Bank Trade Tapes 1988.

In fact contrary to expectations it appears that per capita consumption of meat is levelling off in some of the larger WANA countries (especially red meat). Even poultry production, the main engine of growth in the livestock sector in recent years is faltering, because mounting foreign exchange bills for imported feed have either led to a shortage of concentrates or the removal of subsidies on feed. Here there may well be opportunities for expansion of food legume production to substitute for imported feeds, as suggested by the World Bank.

We conclude from this review:

i) that national projections of demand for food legumes in WANA countries well in excess of population growth are probably correct;

ii) that the optimistic World Bank projections of the growth of demand and supply through the 1980's are also correct, since they have already been fulfilled in advance of 1990 by increasing imports of cool-season food legumes, both into the WANA region, and globally;

iii) that both supply and demand for pulses in WANA and elsewhere are strongly price responsive and that there is scope for increases in P.C. consumption for food, as well as for feed in the region, plus export opportunities if unit costs can be kept down;

iv) that conservative estimates of future demand, assuming low or negative income elasticities for pulses are probably misleading as a guide to research priorities for the food legumes.

v) It is also clear from the recent conclusions of food and nutritional surveys in several countries that it is hazardous to base decisions as to research priorities for individual commodities on regional aggregates of demand, consumption, or trends in production. There are important differences in the factors which determine demand and supply both between different countries, and within individual countries. These are sometime hard to elucidate even after on the spot analysis. Why, for example, does Tunisia show so little interest in growing lentils, when there is no apparent reason why it should not produce them? Why do North African countries seem to prefer Faba Beans, and West Asian countries chickpeas? Why do people eat more bread when they move into urban areas in Tunisia or Turkey, and less in Morocco. Why do rural people eat so much less meat than urban dewellers? Ignoring these factors - which do not show up in an aggregate analysis, could seriously distort research priorities.

2.4. World trade in food legumes

Only 8-10 percent of total world pulse production is traded (compared to 18% in the case of wheat). Haricot beans, peas, chickpeas, and lentils are the most widely traded species. According to the FAO Trade Yearbook (1986), the total value of world pulse exports in that year was $1.87 billion (f.o.b.) and that of imports was 1.90 billion (c.i.f.).

Technically the WANA region as a whole has a small favourable current trade balance in food legumes, but this is misleading since it contains the world's largest exporter of pulses (Turkey), and two other countries (Morocco and Syria) which have maintained a favourable trade balance since 1980, while practically all the remaining countries are net importers (Table 8). These include Algeria, Bahrain, Egypt, Jordan, Kuwait, the Lebanon, Pakistan, Saudi Arabia, the Sudan, Iran, Iraq, Libya, and Cyprus. The largest importers are Algeria, Egypt, Pakistan, Saudi Arabia, and the Lebanon, and the average annual cost to the region as a whole for the period 1980-87 was 232 million U.S. dollars. Gross imports of legumes to the region are projected to rise by over 120,000 tons between 1980 and 1990.

As Table 7 shows, lentils represent much the largest component of imports by WANA countries, being approximately double the volume and value of imports of chickpeas, the next most important cool season legume import, five times as large as pea imports, and six times those of faba beans. Imports of haricot beans to WANA are relatively small. On a world scale lentil trade is also larger than that of chickpeas or faba beans, although it seems to be expanding rather more slowly since 1980/82. Peas are much the largest cool season legume entering world trade, and the fastest growing source of imports. Probably this is because of their wider use and familiarity in developed countries,

Table 8. Imports and exports of cool-season food legumes: West Asia and North Africa: Average 1980-87 Annual Volume (MT) and (US $).

		Lentil		Chickpea		Faba Bean		Peas	Dry	Total	Pulses
		Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports
Algeria	VOL:	26,322	-	29,349	-	577	-	8160		93611	
	VAL:	17849	-	16,634	-	688	-	4487		53462	
Bahrain	VOL:	728	-	530	-	230	-	-		2065	
	VAL:	490	-	321	-	185	-	-		1365	
Cyprus	VOL:	569	173	861	647	89	989	95		3947	3070
	VAL:	368	71	611	484	72	782	54		2826	2289
Egypt	VOL:	47969	-	28	19	-	-	-		54091	267
	VAL:	19605	-	12	13	-	-	-		23931	120
Iran	VOL:	6073	-	1262	11	-	-	8354		17292	
	VAL:	2292	-	577	13	-	-	4547		9191	
Iraq	VOL:	17038	-	14156	-	-	-	-		77134	
	VAL:	8041	-	7724	-	-	-	-		37288	
Jordan	VOL:	1203	691	9201	144	3105	145	207		14901	385
	VAL:	633	262	4322	70	1192	54	95		7388	168
Kuwait	VOL:	3042	772	2305	40	2434	123	-		8417	51
	VAL:	1803	65	1499	34	1226	57	-		5544	40
Lebanon	VOL:	25775	6075	9125	-	6025	-	87		25833	3033
	VAL:	14625	3700	7962	-	3312	-	25		15967	2233
Libya	VOL:	444	-	1267	-	2780	-	596		8366	
	VAL:	670	-	1112	-	658	-	415		6600	
Morocco	VOL:	-	4132	-	2313	-	8588	101	453	268	18468
	VAL:	-	2451	-	1235	-	3796	133	323	356	10235
Pakistan	VOL:	13462	-	4591	158	-	-	19226		41401	674
	VAL:	6680	-	2118	77	-	-	7840		18559	339
Oman	VOL:	-	-	-	-	-	-	-		2396	-
	VAL:	-	-	-	-	-	-	-		1691	-
Qatar	VOL:	1143	-	300	-	-	-	-		1575	
	VAL:	688	-	168	-	-	-	-		929	
Saudi Arabia	VOL:	12095	315	6801	24	10948	16	356		39928	1147
	VAL:	6268	228	3248	16	4131	8	198		19391	1071
Sudan	VOL:	6909		-	-	-	-	-		18819	
	VAL:	4228	-	-	-	-	-	-		11091	
Syria	VOL:	-	15716	4	12684	684	712	104		1433	27987
	VAL:	-	7570	2	4626	511	288	132		1404	11314
Tunisa	VOL:	-	14	1088	402	16	4842	83	21	6695	2278
	VAL:	-	14	623	342	9	1602	50	10	3555	857
Turkey	VOL:	-	254517	-	193,360	4	26121	-	103	5	469,676
	VAL:	-	101174	-	71,738	2	7122	-	52	3	196,422
United Arab	VOL:	126	80	-	-	-	-	-		18000	1400
Emirates	VAL:	76	73	-	-	-	-	-		9500	1050
Yemen Arab	VOL:	-	-	-	-	-	-	-		433	
Rep.	VAL:	-	-	-	-	-	-	-		226	
Yemen PDR	VOL:	-	-	-	-	-	-	-		2800	
	VAL:	-	-	-	-	-	-	-		1327	
United Arab Im:	VOL:	126	80	-						18000	1400
	VAL:	76	73	-						11091	1050
Total region	VOL:	162898	281855	80868	209802	26892	41536	37369	577	439410	528436
	VAL:	84316	115608	46933	78688	11986	13709	17976	385	233185	226138
Unti Value/Ton		518	410	580	375	446	330	481	667	531	428

especially within the EEC, which absorbs the bulk of pea imports, both for human food and animal feed.

Total world export trade in pulses averaged 3.9 million tons for 1984-86 - approximately 8 percent of world production. Developed countries account for over 50 percent of these exports, nearly all of which goes to the EEC. A good deal of this is intra-regional trade within the EEC, but Canada and Turkey have both expanded production and exports rapidly during the 1980's - Canada's legume production having grown from 180,000 tons to nearly a million tons over about the same time as the Turkish expansion referred to below. In 1987 Canada exported 148,000 tons of lentils and 288,000 tons of field peas, a total of 436,000 MT. 75% of the United States dry pea, chickpea, and lentil production of 510,000 tons is also exported. Mexico has expanded chickpea exports to 70,000 tons, and Burma is reported to be aiming to raise its pulse area from 800,000 ha to 1.5 million ha over the next decade. Although it is not exporting significant quantities of cool-season legumes at present it is a large and fast-growing chickpea producer, as well as a large bean (Phaseolus) exporter. The EEC countries and Australia are also expanding pulse production; in 1988/89 the latter had about 513,000 ha under field peas, 933,000 ha of lupins for feed, 61,000 ha of chickpeas, and 43,000 ha of faba beans, but no significant area of lentils. The 1988/89 harvest was 560,000 tons of peas, 1,079,000 tons of lupins, 71,000 tons of chickpeas, and 46,000 tons of faba beans.

There is only one major exporter from the WANA region - Turkey, although Morocco and Syria have been both exporters and importers in the past, and are anxious to recapture some of their lost ground in exports. Turkish pulse exports, both by private traders and through the Turkish Grain Board (TMO), have risen rapidly, from about 274,000 M.T. in 1980 to 534,000 M.T. by 1986; while total production there is now 2.2 million tons. Turkey exports legumes to other WANA countries, to the EEC, to the USSR, and to South Asia, especially India. These exports were valued at 189, 180, 171, and 220 million dollars in 1983, 1984, 1985 and 1986, respectively, and have consistently occupied fourth or fifth place in the fifteen categories of Turkish Agricultural Exports since 1983, representing from 8.8 to 12% of the total value of all Turkish exports over that period.

Thus the world supply of cool season legumes has expanded substantially since 1980, with new exporters entering the field. This is apparently due in part to a run of poor crops in North America which pushed up legume prices, and in part to unusually low cereal prices, so that farmers have been moving out of cereals into producing legumes for food, and to a lesser extent for feed-especially lupins. Recently, however, considerable pulse stocks have accumulated, leading to a decline in prices.

One authority (Huttmann 1988), is not optimistic about new importing countries entering the buyers market on a large scale; instead the signs point to increasing competition. He therefore stresses the need to try and expand demand and end uses for pulses, through nutritional education campaigns, promotional drives (the Turkish Grain Board has developed an impressive publicity effort via radio, T.V. newspaper, publishing cookbooks, etc.); improved packaging; canning and reprocessing; and research on their value as animal feed. In the case of chickpeas and lentils promotional campaigns to expand consumption, and research to increase their end-use flexibility are the most promising approaches. Lentils in particular would benefit from a wider range of end uses; chickpeas probably have a broader base. However, in attempting to improve seed yields of lentil it is important that plant breeders do not overlook the value attached by many farmers to its straw for forage.

Thus while the Turkish experience shows that legumes, especially lentils, can be a valuable component of foreign exchange earnings for developing countries, it is likely to become more difficult to maintain a firm foothold in the world market on a haphazard basis. Buyers like to have an assured supply of an acceptable quality and price to meet their needs. The assurance of supply is a particular problem for countries of the WANA region, where highly variable precipitation causes large inter-annual fluctuations in production of rainfed crops. This has been both a cause of increasing difficulties in meeting domestic demand and of unreliability in supplying export markets by countries such as Syria and Morocco. Since lentils tend to be grown both at higher elevations and in drier ecozones than the other three cool-season food legumes this makes them especially vulnerable to weather anomalies.

In the opinion of one private exporter from Turkey, (Sami Aji 1988), his country is the only one in the region able to provide the world market with a continuous and stable supply of chickpeas because of its relatively stable yields, even though he contrasts Turkish methods of presentation to consumers unfavorably with those of Spain, resulting in lower prices.

He is cautiously optimistic concerning red lentils, for which he sees a surplus of 100,000 to 150,000 tons developing over current Turkish domestic consumption of about 100,000 tons and exports of 250,000 tons. While red lentils store well and the Turkish production and market position is quite strong, he notes that this crop is more sensitive to climatic conditions than chickpea, and fears that unless higher-yielding varieties, better adapted to irrigated conditions, can be developed, production will decline sharply if prices fall due to over-supply. This would be a serious economic blow to Turkey.

He believes that green lentils present more of a problem. There is a world import demand of around 305,000 tons, whereas export availability recently exceeded 400,000 tons. They have a shorter shelf life than red lentils or chickpeas, and Turkey faces stiff competition from North American exporters with lower production costs due to mechanization, who can even undersell her on neighboring markets such as Greece and Egypt. N. American green lentils are apparently favored in European markets and Japan, because they are free of pests- especially Bruchus, and are well graded. Thus, unless price per unit can be reduced and quality improved, Turkey may face difficulties not only in expanding its exports to European countries, but even in retaining its exsisting market share. Other hopeful exporters from West Asia and North Africa will face similar problems with less experience than Turkey.

It is noteworthy in this context that the World Bank also stresses the need to keep down costs per unit of production. It draws attention to the importance of market research by aspiring developing country exporters into the specific types of pulses demanded in both developed and developing country markets, competitive prices, and requirements for quality, grading, packing, and delivery.

The various aspects of market research and development discussed above tend to be neglected at International Agricultural Research centers and in national research programmes. ICARDA may need to review its research priorities in this field, not only with respect to lentils, but also to identify opportunities for expanding exports of other cool season legumes for food, feed, and forage along the lines indicated by the Bank's projections and emerging trends in world markets, e.g. for peas vetches, and lupins. At the same time a continuing effort to raise yields of lentils and reduce their yield variability through improved resistance to abiotic stress, as well as to reduce production costs, is essential. It is not only the second most widely consumed food legume in the region at present, but also the one which is most widely traded there.

2.5. <u>Trends in area and yield growth of food legumes by region</u>

Globally area of food legumes has risen by about 2.2 percent a year since 1980, yields by only 0.3 percent, and production by 2.5 percent. By contrast cereal area has barely increased but yields and production have grown by just over 2.3 percent. World wheat area has actually fallen since 1980, but yields increased at almost 2.4 percent annually, so production grew by 2.3 percent. Cereal yields in the developing countries overall rose by 17% from 1.894 tons/ha in 1979/81 to 2.220 tons ha in 1984/86; while those of wheat rose from 1.635 tons/ha to 2.096 tons/ha over the same period, an increase of 28 percent. <u>The 1984/86 world yield average for the cereals was 2.55</u>

tons/ha whereas that of the legumes was 783 kg/ha - less than a third of that for the cereals. There is also a significant gap between food legume yields in developed and developing countries. They are currently 1.45 tons/ha in the former compared to only 630 kg/ha in the developing countries. Yields have risen 35% in 5 years in developed countries: only 4% in the developing. This highlights the need for research to improve yields in the Third World, and suggests that there is a great deal of scope for doing so, both through breeding and crop management.

Among developing regions as defined by FAO, the Near East (which includes Egypt, Libya and the Sudan but not the Maghreb countries), has the highest average yields, about 1.05 tons/ha in 1984/86, but very poor overall performance in improving yield since 1979/81 when the average was 1.15 tons/ha. Average yields in the Maghreb countries are rather lower, pulses there being entirely rainfed; and there has been little improvement - the average for 1985-87 being 646 kg/ha compared to 556 kg/ha in 1979/81. Growth in the WANA region as a whole since 1970 has depended almost entirely on a substantial expansion of nearly 60 percent in the pulse area. By contrast food legume yields in the South and East-Asian countries, although much lower in absolute terms, rose by 15 percent over the same period, whereas the area expanded by only 3 percent. Pulse area also expanded in Africa - by about 16 percent over the period, but yields stagnated. The same is true of Latin America.

3. Food legumes in the ICARDA region

Chapter 2 provides data on the main species of food and forage legumes indigenous to the region, and their economic and dietary importance both globally and within West Asia and North Africa. This chapter will focus on their role in the agriculture of that region, where they are mainly grown, how their production has developed over the last two decades, and the nature of the principal sources of growth.

3.1. The main species cultivated in the region and their importance

Table 9 shows the distribution of total food legume area in the main producing countries of the region and the changes which have taken place since 1970, compared to the total arable area in each country.

It will be seen that while the latter has changed hardly at all overall, and has remained almost static since 1980 even in countries such as Algeria and Morocco where there was some expansion in the previous decade; the area of food legumes has increased by 55 percent between 1969-71 and 1986-88. Taking 1969-71 as 100 the indices are: 1979-81 = 116; and 1986-88 = 156. Taking 1979-81 as 100, the 1986-88 index is 135. Thus growth has been much faster during the 1980's than the 1970's, confirming and exceeding the World Bank analysis referred to in chapter 2.

At the individual country level, however, there are marked differences in the pattern of expansion of food legumes since 1970. The overall regional rate of growth is somewhat biased by the huge increase in Turkey, most of which has occurred since 1980 as a result of the strong campaign there to replace fallow in rainfed farming by a legume crop. However even if Turkey is excluded, growth in the rest of the region has accelerated. Other countries which have increased food legume area significantly are Algeria, Iran, Sudan, and Morocco. Tunisia increased its food legume area sharply in the 1970's but growth has since fallen off even faster. Area fell between 1970 and 1980 in Cyprus, Egypt, Morocco, Syria, Jordan, Lebanon, and Iraq. In Egypt, Syria, and Morocco the food legume area has risen to above the 1970 level since 1980; but in the other three countries and in the Yemen Arab republic it has continued to decline in the 1980's. Thus although the share of food legumes in total arable area has risen for the region as a whole from 3.2% in 1970 to 3.7% in 1980, and about 5% in 1988, the share of the arable area within each country occupied by food legumes has fluctuated with time*. There are also considerable differences

* The area covered by food legumes is now equivalent to 13 per cent of cereal area, whereas the figure cited in the EPR (1989) report, apparently based on 1984/86 FAO data, is only 8 per cent.

Table 9. WANA Share of Food Legumes in the total arable area 1970, 1980, 1987, and changes over time.

Country	Area	Harvested	(000 ha)	% Change in Pulse area			Total arable area		(000/ha)	% change in total arable			Share of pulses in total arable %		
	1969-71	1979-81	1986-88	70-80	80-87	70-87	1970	1980	1985	70-80	80-87	70-87	1969-71	1974-81	1986-88
Algeria	87	120	161	38	34	85	6,248	6,875	7000	10	2	12.0	1.35	1.48	2.30
Egypt	185	141	166	-24	18	-10	2,843	2,445	2,320	-14	-5	-18.5	6.50	5.80	7.16
Libya	ND	8	9	ND	12	ND	1,725	1,753	1,787	2	2	3.6	ND	0.46	0.50
Morocco	425	388	518	-9	33	22	7,076	7,530	7,880	6	5	11.4	6.01	5.15	6.57
Sudan	62	76	96	21	26	52	11,665	12,360	12,420	6	0.5	6.5	0.54	0.61	0.77
Tunisia	112	159	105	42	34	-6	3,250	3,190	3,398	-2	6	4.5	3.45	4.98	3.09
Total North Africa	872	892	1,055	2	18	21	32,807	34,153	34,805	4	2	6.0	2.66	2.61	3.03
Cyprus	17	7	5	-59	-29	-71	365	365	365	0	0	0	4.65	1.92	1.37
Iran	206	241	531	17	120	158	15,150	12,981	14,100	-15	8	-7.0	1.36	1.86	3.77
Iraq	51	46	38	-10	-17	-25	4,848	5,250	5,250	8	0	8.3	1.05	0.88	0.72
Jordan	31	13	14	-58	8	-55	340	360	380	6	5	11.1	9.12	3.61	3.68
Lebanon	13	10	10	-23	0	-23	240	215	210	-10	-2	-11.8	5.42	4.65	4.76
Pakistan	1,354	1,684	1,400	24	-17	3	19,161	19,994	20,100	4	0.5	4.8	7.06	8.42	6.97
Syria	230	220	230	-4	4	0	5,651	5,230	5,038	-7	-4	-10.9	4.07	4.21	4.57
Turkey	538	719	1,944	34	170	261	24,793	25,354	24,606	2	-3	-0.8	2.17	2.84	7.90
Yemen Arab R.	47	73	27	55	-63	-43	1235	1,261	1,261	2	0	2.1	3.80	5.79	2.14
Total W. Asia	2487	3,013	4199	21	39	69	71,789	71,010	71,310	-1	0.4	-0.7	3.46	4.24	5.90
Total WANA Region	3,359	3,905	5,254	16	35	56	104,596	105,163	105,163	0.5	0.9	1.4	3.21	3.71	4.95

Sources: FAO Production yearbooks and national data.

between countries of the region, from a low 1986/88 value of under one percent of arable area in Iraq, the Sudan, and Libya to 7.9% in Turkey, about 7% in Egypt and Pakistan, and 6% in Morocco. These four latter countries, together with Iran, and Syria, are the largest producers in the region. The countries where food legume area appears to be stagnant or in continuing decline are among the smallest producers, Cyprus, Iraq, Jordan, The Lebanon, and Libya.

Table 10 shows the distribution of production of the main food legumes species in the same countries over time and ranks their order of importance in each country. There are marked contrasts between the countries of North Africa and those of West Asia.

In North Africa the dominant food legume without exception is Vicia faba, production of which is five times greater than that of chickpea, the second most important species, and nearly five times that of the third species, lentils. In this light the strong feelings expressed by policy-makers and research workers there concerning the TAC recommendation to phase out the ICARDA faba bean programme are understandable.

In West Asia lentils are currently the most important species in terms of production in Jordan, Syria and Turkey; but not in Iran or Pakistan, where chickpeas are currently much more significant. Overall chickpeas represent a somewhat higher share of total production. However, compared to chickpeas and lentils the position of faba beans is reversed from that in North Africa, production of this crop being only about a ninth that of lentil and a twelfth of chickpea in West Asia. Haricot beans (Phaseolus sp:), are becoming increasingly important in West Asia, both under rainfed conditions where there is some summer rainfall (as in parts of Turkey and Iran) and under irrigation. Green and dry peas are of lesser importance and their area is increasing more slowly than that of beans.

Other food legumes and forage legumes grown for seed are of relatively minor importance for the region as a whole. Vetch and

Table 10. Production of main food legumes species by country (000 MT) West Asia/ North Africa, and ranking of their importance by country and for region 1974/76 and 1985/87.

		Algeria		Morocco		Tunisia		Egypt		Sudan		Iraq		Jordan		Syria		Turkey		Iran		Pakistan		Total N. Africa		Total W. Asia			
		Prod.	Rank	Prod.	Rank	Prod.	Rank	Prod.	Rank	Prod.	Rank	Prod.	Rank	Prod.	Rank	Prod.	Rank	Prod.	Rank	Prod.	Rank	Prod.	Rank	Rank		Rank		Total	Rank
Lentil	1974-76	7	3	34	4	1	3	43	2	-		4	4	15	1	95	1	155	2	30	3	27	3	87	4	326	3	413	3
	1985-87	2	5	55	2	1	3	15	2	-		4 .	4	5	1	61	1	806	1	46	4	30	4	73	3	952	2	1025	2
Chickpea	1974-76	22	2	92	3	23	2	5	4	2	3	7	3	3	2	46	2	179	1	39	2	588	1	144	2	862	1	1006	1
	1985-87	17	2	55	2	31	2	15	2	2	3	12	1	1	2	40	2	593	2	73	2	564	1	120	2	1283	1	1403	1
Faba bean	1974-76	30	1	263	1	45	1	241	1	18	1	17	1	-		10	3	51	4	-		-		597	1	78	4	675	2
	1985-87	22	1	193	1	36	1	302	1	49	1	8	2	1	3	13	3	80	4	-		-		602	1	102	5	704	3
Pea	1974-76	3	4	112	2	-		5	4	-				-		1	5	3	5	22	4	-		120	3	26	5	146	5
	1985-87	3	3	42	4	-		4	5	-		-		-		1	5	5	5	49	3	68	3	49	4	123	4	172	5
Haricot Bean	1974-76	3	4	2	5	-		16	3	3	2	8	2	-		8	4	155	3	101	1	57	2	24	5	329	2	353	4
	1985-87	3	3	10	5	-		14	4	2	3	6	3	-		10	4	176	3	166	1	121	2	29	5	479	3	508	4
Total Pulses	1974-76	65	9	505	3	69	7	310	4	23	8	36	10	18	11	160	5	543	2	192	6	672	1	972	-			2593	-
and ranking of countries	1985-87	47	9	355	3	68	8	350	4	53	7	30	10	7	11	125	6	1660	1	334	5	783	2	873	-			3812	-

lathyrus seed production for forage production is of some importance in Morocco, Syria and Turkey; but no other legume species has the same economic and social importance as Chickpea, lentil, and faba bean.

3.2. The value of the main food legumes

Based on 1980/87 world import price data the position is shown in Table 11. The position of lentil chickpea, and haricot beans is somewhat enhanced because their average import values in dollars are higher than those of Faba beans, and peas, although their overall earnings are in the same rank order as those for their production.

The prices used for these calculations are derived either from 1986 or 1987 international price series data in the FAO Trade Yearbook (Lentils and peas); or U.S. and Canadian trade data derived from the June 1989 Canadian pulses report published by Agriculture, Canada (Faba Bean, Chickpea, and Phaseolus Beans). Where dated are quoted as FOB they have been adjusted according to the FAO convention by multiplying by 112.

There are striking differences between the world price data for cool-season legumes and cool-season cereals (wheat and barley). Average 1987 wheat prices listed in the FAO series are US $ 128/M.T. for U.S. Hard Winter No. 2 converted to CIF, and US $ 149/MT C.I.F. for Canadian West Red Spring No. 1. Canadian Barley prices were extremely low $ 63/M.T. C.I.F. However both wheat and barley prices firmed up in 1988 following the two U.S. drought years, Hard Winter No. 2 rising to around $ 180 a ton at CIF rates by the last quarter of that year, and barley to $ 114 a ton. According to CIMMYT (1989) this rather dramatic increase is not expected to reverse the long-term pattern of low world wheat prices, and even at 1988 world prices most of the cool-seasons food legumes have a price advantage over wheat of 2 to 3 times, and considerably more over barley prices.

These price comparisons suggest that where producing countries are deficit in food legumes they should be giving high priority to increasing their domestic supply in order to reduce imports even if

Table 11. Value of food legumes in WANA at world import market prices 1984/86.

	Lentil	Chickpea	Faba bean	Haricot Bean	Pea	Total
Price per MT (CIF)	$ 509	$ 530	$ 321	$ 709	$ 462	-
Algeria	1020	11660	7062	2127	1386	23255
Morocco	28,050	29150	61953	7090	19404	145647
Tunisia	510	16430	11556	0	0	28496
Egypt	7,650	7950	96942	9926	1848	124316
Sudan	0	1060	15729	1418	0	18207
N. Africa	37,230	66,250	193242	20561	22638	339921
Iraq	2040	6360	2568	4254	0	15222
Jordan	2550	530	321	0	0	3401
Syria	31,110	21,200	4173	7090	462	64035
Turkey	411,060	314,290	25760	124784	231	876,125
Iran	23,460	38,690	-	117694	22638	202,482
Pakistan	15,300	298,920	-	85789	31416	431425
W. Asia	485,520	679,990	32,822	339,611	54747	1,592690
Total WANA	522,750	746,240	226,064	360,172	77385	1,932611
Crop as % total						
N. Africa	10.9	19.5	56.8	6.1	6.7	100.0
W. Asia	30.5	42.7	2.1	21.3	3.4	100.0
Region	27.0	38.6	11.8	18.6	4.0	100.0

this means increased imports of wheat or barley. If countries of the region have a comparative advantage for legume production in ecological terms and can produce at costs comparable with world import prices they might attempt to develop exports of legumes for food or feed. This might be a better use of domestic resources than attempting to use even more land for production of rainfed cereals, which can be imported at a third of the price of food legumes and do not produce an equivalent gross value per hectare at current average yields. The problems lie in the higher production costs of food legumes, their higher labour demands, and in a tendency for governments to support cereal prices but not those of the legumes. We shall discuss these problems further in Section 4.

3.3. Changes in area, yield and production over time

Table 12 shows how area, yield, and production of food legumes in the WANA region have changed over time, and Annex Tables 1 to 7 shaw the relevant growthrates for the main species in seven of the most important producing countries. Where data permitted these have been calculated for the long-term and two shorter periods with 1980 as the dividing line.

The pattern of growth varies widely, by species, by country, and over time. In the case of legumes generally, however, production performance over the years since 1970 has been uneven, and in several countries disappointing. It has relied heavily on area expansion for growth, while productivity growth through increased yield has contributed little. Until recently this was in sharp contrast to wheat, where area has expanded little but yields have risen significantly as a result of a combination of the widespread adoption of high-yielding varieties, increased use of chemical fertilizer, herbicides, mechanization, and improved tillage practices. Few really outstanding new varieties of the main food legumes have been available until recently, (we shall examine progress in this respect in more detail later); fertilizer use is low and often non-existent, selective herbicides for control of broad-leaved weeds tend to damage the legume crop, and mechanization is more difficult than for cereals, especially

Table 12. Area (000 ha) yield (kg/ha) and production (000 MT) of cool season food legumes, West Asia and North Africa: 1974/76 and 1985/87.

			Algeria	Morocco	Tunisia	Egypt	Sudan	Iraq	Jordan	Syria	Turkey	Iran	Pakistan	Total	% change 85/87 74/76
Lentil	1974-76	Area	17	50	3	26	-	5	20	110	142	40	81	494	
		Yield	426	688	488	1622	-	845	776	868	1090	748	362	836	
		Prod.	7	34	1	43	-	4	15	95	155	30	29	413	
	1985-87	Area	9	87	2	9	-	5	7	74	734	96	62	1085	119.6
		Yield	215	641	667	1635	-	737	658	822	1097	478	492	945	13.0
		Prod.	2	55	1	15	-	4	5	61	806	46	30	1025	148.0
Chickpea	1974-76	Area	33	119	41	3	2	12	6	71	151	35	1058	1531	
		Yield	666	774	553	1681	945	575	588	645	1188	1115	556	657	
		Prod.	22	92	23	5	2	7	3	46	179	39	588	1006	
	1985/87	Area	63	81	41	9	1	16	2	67	533	101	1043	1957	27.8
		Yield	272	678	750	1607	1067	791	529	623	1103	721	541	717	9.1
		Prod.	17	55	31	15	2	12	1	40	593	73	564	1403	39.5
Faba Bean	1974/76	Area	35	213	80	106	15	18	-	6	31	-	-	504	
		Yield	864	1234	563	2267	1203	978	864	1608	1612	-	-	1339	
		Prod.	30	263	45	241	18	17	-	10	51	-	-	675	
	1985/87	Area	77	203	60	125	30	7	1	8	45	-	-	556	10.3
		Yield	412	954	615	2429	1653	1018	553	1605	1805	-	-	1266	-5.5
		Prod.	22	193	36	302	49	8	1	13	80	-	-	704	4.3
Pea	1974/76	Area	6	127	-	3	-	-	-	1	3	22	-	162	
		Yield	574	881	-	1743	-	-	-	768	1350	1220	-	938	
		Prod.	3	112	-	5	-	-	-	1	4	27	-	152	
	1985/87	Area	10	52	-	3	-	-	-	1	3	67	144	279	72.2
		Yield	342	795	-	1453	-	-	-	887	2024	725	476	616	34.3
		Prod.	3	42	-	4	-	-	-	1	5	49	68	172	13.2
All pulses	1974/76	Area	97	570	145	168	70	49	32	264	599	195	1496	3685	
		Yield	695	953	557	2058	1067	769	716	800	1163	1028	522	831	
		Prod.	67	543	81	346	74	38	23	212	697	200	781	3062	
	1985/87	Area	167	515	124	172	92	78	14	206	1731	498	1472	5069	37.6
		Yield	341	807	652	2261	1225	826	615	769	1077	704	542	840	1.1
		Prod.	57	415	80	387	113	31	6	156	1867	350	797	4259	39.1

for lentils, because of their short stature.

The general pattern outlined above is consistent when the sources of growth from 1974 to 85/87 are reviewed below for individual species. Lentil. For 10 countries area increased in four of the biggest producers Turkey, Iran, Morocco, and Syria; but fell in one large one (Pakistan), and four smaller ones. Nevertheless there was a net increment to area of 600,000 hectares. Yields rose in only three out of 10 countries, and both area and yield increased in only one (Turkey). Production rose in four countries, remained stationary in two, and fell in four.

The lentil situation is not entirely bleak, however for where production has expanded it has occurred in the larger producers, Turkey, Morocco, Iran and Pakistan; the one major exception prior to 1988 being Syria. The effect of this (mainly due to the huge expansion in Turkey), is to increase lentil production for the aggregate of the seven countries by 612,000 tons between the mid 1970's and the mid-1980's.

A further cause for optimism is the large increase in lentil area and a smaller increase in yield reported for Syria in 1988, resulting in production there almost doubling over 1987 to reach 185,000 metric tons - the highest level yet recorded in that country. There was also a further increase of 25,000 tons in Turkey in 1988.

In both Syria and Turkey lentil yields in that year exceeded 1 ton/ha: for the West Asia/North Africa region as a whole they are somewhat above those in other developing regions, and approaching yields in developed producing countries such as Canada and the United States. Variability is high, however, as shown in Table 13, P:48. Two countries with exceptionally low yields are Algeria and Pakistan; in the latter yields approximate those in India.

In Algeria there may be a statistical anomaly - self - consumption for food and seed by farm families is not included in the production data, and here and in other countries of the region it is equivalent to 40-50 percent of total output. This makes yields appear lower than they actually are. Wide row - spacing is often used to facilitate mechanical weed control in lentils in Algeria - this can range from 60 cm between rows to as high as 2.5 meters, whereas the 'recommended' spacing is 17 cm. Thus there is a very large trade-off between the yield gains from better weed control, and the reductions due to wider row spacings. In Pakistan weeds are also a very serious problem in lentils, more so perhaps than in Algeria because they are grown under a relatively favourable moisture regime in Pakistan (compared especially to chickpeas), weeding is not mechanized, and they are often intercropped with wheat - making weed control difficult.

Chickpea. The performance of chickpea has been slightly better than that of lentil over time, production having risen in five out of eleven countries. However this has also been primarily the result of area expansion; yields declined between 1974/76 and 1985/87 in eight of eleven WANA countries, including the five largest producers (Turkey, Pakistan, Iran, Morocco, and Syria). Only in Iraq and Tunisia is there any noticeable yield improvement. Both area and yield increased in Iraq, but that is a fairly small producer. However mainly because of the large area increase of 382,000 ha in Turkey there was a net increase in production of 400,000 tons: a similar pattern to that noted for lentil.

When looking at regional averages it is easy to be misled by the impact of large producers. Turkey tends to impart an upward bias, since its pulse area has been the fastest growing in the region and is now the largest, while its yields are the highest and most stable next to Egypt where all pulse production is irrigated. Pakistan, on the other hand exerts a downward bias especially for chickpea, since its area of this crop is much the largest (double that of Turkey), and its yield almost the lowest. In that country chickpeas are grown in an extremely harsh environment - the Thar desert, where yields are so low and unreliable that producers will not weed and use no improved technology, whereas in most other WANA countries this crop is grown under relatively favourable moisture and temperature conditions, especially compared to lentil. For chickpea this situation leads to a statistical anomaly whereby the large low yielding chickpea area in Pakistan drags down chickpea yields for the whole region, so that they average only 627 kg/ha for the seven country mean, compared to 823 kg/ha for lentils. Since Pakistan produces chickpeas almost entirely in the harshest environment of any country in the region, it is not unreasonable to calculate a separate average yield for the six other countries. This raises lentil average yields to 885 kg/ha, and chickpea yields higher still to 895 kg/ha. For West Asia alone the differences are larger, lentil yields are 945 kg/ha but chickpeas go up to 1.01 tons. Overall the result indicates a net gain in area, yield, and production of chickpea for the countries other than Pakistan, where all three components decline marginally.

Faba Bean area rose between 74/76 and 85/87 in five out of nine countries and in three important producers (Egypt, the Sudan, and Turkey), both area increase and yield increase contributed to the growth of production. For the nine countries which grow the crop there was a small net increase in production. (Iran and Pakistan do not produce significant quantities). Even so production fell in half of the countries covered - including the three Maghreb countries where Faba bean is the most important food legume. Yields for faba beans in Egypt, the Sudan, Iraq, Syria, and Turkey exceed a ton to the hectare, and in Egypt are over 2 tons. For the Maghreb they average only 738 kg/ha. This is disturbing even allowing for the probability that all the crop is irrigated in Egypt and a higher proportion in other West Asian countries.

With lentils and (except for Tunisia) with chickpeas the situation in the Maghreb is also disquieting. For Algeria and Morocco production of food legumes as a whole fell by about 140,000 tons (over 20%), between 1970/6 and 1985/8. Tunisian production stagnated overall but except for the case of Faba bean, did not decline. Production of all three major crops fell in Algeria: lentil gained 20,000 tons in Morocco, but there were massive declines of nearly 40,000 tons in chickpea, 70,000 tons of Faba Bean and 50,000 tons in peas. Algeria, which exported 44,000 tons of food legumes in 1928 imported 98,000 tons in 1987, despite a reported increase in their area of 190,000 ha since 1964 (Benbelkacem 1988). According to his estimate, an area of 200,000/ha with a yield average of 825 kg/ha is needed to satisfy demand there; average yields at present are 341 kg/ha, and the area is 167,000 ha. Morocco which was a major exporter had to put a 3 - year moratorium on exports in the early 1980's to avoid large imports or higher consumer prices, and its 1987 exports of all legumes amounted to only about 18,000 tons. This is a serious situation, since food legumes are of considerable dietary importance in the Maghreb countries and governments in both Algeria and Morocco are projecting higher growthrates of per caput consumption for the 1990's.

Peas and Phaseolus (haricot) beans are of increasing importance in the region. Peas have almost equalled lentils in importance as the third - ranking food legume in Morocco, Iran and Pakistan; while haricot beans rank first in Iran, second among sub-tropical food legumes in Pakistan, and third next to lentils and chickpeas in Turkey , and Egypt. Overall, however, phaseolus beans still rank fourth in importance in WANA, and peas come last.

3.4. Yield Variability of lentil, chickpea, wheat, and barley yields has been calculated for seven countries of the WANA region, and for Canada - probably the region's main current competitor in the export market (Table 13). Generally variability of legume and cereal yields is higher in North Africa than in West Asia, and this may be one reason for the slower progress in raising production there. In our discussions with farmers and government field staff there we noted a prevalent impression that lentils and chickpeas were less reliable and more risky crops than winter cereals and forage crops.

A problem with high variability is that it requires very large changes in the dependent variable to obtain significant trends in growthrates of area, production, or yield, by regression analysis, even when using fairly long time series for the variable being measured.

Thus great caution needs to be exercised in interpreting the national growth rates of the area, production, and yield for cereals and legumes in Annex Tables 1-14. Some significant differences can be identified, even at the 1 percent level of confidence, but there are also some quite large rates of change which are not statistically significant and may be due to random factors. This is particularly likely to be the case with yields because they are so vulnerable to the highly variable year - to - year rainfall in most of the region. Major exceptions are Pakistan and Turkey with rather low C.V.s; possibly because of the influence of irrigation in the former, and the absence of any really large areas of low rainfall, or desert influences on climate in the latter.

Paradoxically, the variability of yield (which is generally high for both crops), is not always lower for chickpea, despite their being produced in higher rainfall ecozones. In Syria, Morocco and Pakistan (three large chickpea producers), its variability is considerably higher than that of lentil; in Jordan, and Turkey the reverse is the case although the magnitude of the range is somewhat smaller. In Algeria and Morocco the coefficients of yield variability of wheat and barley are lower than those of either legume crop; in the other five countries there is very little difference - <u>especially for lentils</u>, which actually show less variability than wheat or barley in Tunisia, Syria, and Turkey and are about the same in Jordan and Pakistan. <u>Chickpea</u> compares less well with the cereals in Morocco, Syria and Pakistan but does very well in Turkey.

Except in Pakistan, where chickpeas are at an ecological disadvantage, the reasons for this situation are not clear, but it may be related to the greater susceptibility of chickpea to unpredictable attacks of disease - especially Ascochyta blight and wilt compared to the lentil crop.

The long-term coefficient of variability of <u>lentil</u> in Canada, the largest developed country producer, is much <u>higher</u> than the mean c.v. for the seven WANA countries, and although the latter may be biased downward by the low CV of Turkey, lentil C.V.'s are well below those of Canada in all of the main producers except Algeria and Jordan. (Chickpea production is unimportant in Canada). The Canadian C.V. for wheat, on the other hand, is below that in all seven WANA countries, only Turkey and Pakistan being reasonably close. This may be because wheat is grown over a much wider area of Canada than lentils with generally more stable climatic conditions, whereas the latter are concentrated into an ecological niche of higher weather variability. Wheat research and production expertise are probably more developed in Canada, wheat having long been a crop of huge economic importance there, whereas lentils were quite insignificant prior to 1980 and still are relatively so, being equivalent to less than 3% of the wheat area. Nevertheless, Canadian average yields of lentils have improved from 822 kg/ha 1979-81 to 1243 kg/ha for 1985-87, an increase of 51 percent. Over the same period, Turkish yields have only risen 3 percent to 1098 kg/ha. ICARDA material is now being widely used in Canada in crosses to provide resistance to Ascochyta blight, the key Canadian production problem. This is also true of the Western United States.

Table 13. Long-term Coefficients of Variation (%) of Area, Production, and Yield of cool-season pulses and cereals; selected countries of N. Africa and West Asia, and Canada.

Country	Lentil Area	Lentil Prod.	Lentil Yield	Chickpea Area	Chickpea Prod.	Chickpea Yield	Wheat Area	Wheat Prod.	Wheat Yield	Barley Area	Barley Prod.	Barley Yield
Algeria	32.0	63.3	50.4	23.0	41.5	39.6	17.6	26.4	21.1	27.0	53.6	25.5
Morocco	42.2	61.1	35.6	41.5	71.8	42.6	9.7	30.3	24.3	8.4	33.1	31.7
Tunisia	98.2	90.8	21.8	20.8	29.5	20.7	9.3	28.0	27.5	33.0	49.5	28.8
Jordan	49.4	86.8	50.7	112.4	150.1	41.7	32.5	73.6	43.7	26.3	61.9	45.3
Syria	40.0	40.5	19.4	38.0	46.1	48.0	13.1	21.3	23.5	16.1	52.8	51.1
Turkey	80.5	82.0	13.2	61.2	60.0	9.9	3.0	18.6	16.6	10.8	25.3	16.6
Pakistan	20.2	16.5	14.3	10.9	21.3	42.6	9.5	22.5	14.1	17.9	18.4	3.8
Canada	124.6	155.2	40.8	-	-	-	20.8	27.3	12.8	-	-	-

Source: Calculations undertaken by IFPRI from regression analysis of long-term national trends: Algeria 1970-86; Morocco 1970-88; Tunisia 1972-85; Jordan 1970-84; Pakistan 1970-87; Syria 1975-87; Turkey 1970-87; Canada 1983-87.

4. Agricultural Growth in West Asia and North Africa and the Role of the Legumes

4.1. The changing dynamics of agriculture in the 1990's

In section 1 attention was drawn to the dynamic nature of agriculture in the WANA region consequent on its fast-growing population (about 415 million in 1987 compared to 300 million when ICARDA was conceived in 1976) rising *per capita* income, and increasing urbanization. In addition, the influence of the rising flood of tourists, and the improvement in the educational levels of the regions' population must be taken into account. It is difficult to predict the long-term effects of all of these trends on demand for agricultural products, and thus on land use in the region, but some of them are already becoming apparent. These include:

- An increase in rainfed cropping intensity and diversity consequent on a substantial reduction in the area of fallow and a corresponding increase in the area of annual and perennial food crops.
- A decline in the area of pasture to allow new land to be brought into cultivation.
- A rapid expansion in mechanized cultivation and harvesting to facilitate the above changes.
- An increase in numbers of small ruminant livestock, but a reduction in their feed supply due to ploughing up of pastures, fallows, and stubbles.
- A large expansion in poultry meat and egg production necessitating increased feed imports.
- An increase in rainfed barley area, partly at the expense of wheat (where more is being grown under irrigation), but also in place of fallow and marginal grazing, and through the development of continuous cereal systems.
- An increase in food legume area, but (as also with barley), little improvement in yield for lack of high yielding varieties.
- An increase in production of annual forages, but not fast enough to compensate for the loss of natural grazings, despite the development of closer integration of crops and livestock in settled farming systems in higher rainfall areas.
- A rise in the price of cereal and legume straw (especially barley

and lentils), to meet demand for animal fodder.

- A considerable expansion of vegetable and potato production, especially in irrigated land; as well as of fruit, nut and olive production in both rainfed and irrigated areas. Horticulture and poultry production have been the fastest growing components of agriculture in most WANA countries, driven partly by high income elasticities of demand, and urbanisation; and partly by export opportunities (e.g. in Morocco, Tunisia and Turkey).
- Increasing competition for labour both between agriculture and other sectors, and within agriculture. While labour intensive industrial crops and vegetables may be the most affected there is recent evidence of pressure on cereals and pulses. A rapid expansion of mechanized cereal harvesting and straw baling is one result of this pressure.
- Increasing competition for land and for water between agriculture and other sectors, of which a symptom may be the rising pressure to eliminate fallow and to intensify farming systems.

While the full implications of all these changes in demand, and responses on the supply side, for future production of food legumes are not yet clear it must be noted that even if income induced demand for pulses as food does not rise faster than population growth (and this is contrary to most of the projections referred to in section 2 as well as against current trends), the supply of food legumes will have to increase to provide an average of 6.9 kg per capita per year to another 201 million people by the year 2000. This implies a total increase of 1.39 million metric tons at current average yields which would mean bringing another 1.70 million ha of land into food legume production over the next decade, with 410,000 ha of lentils, 500,000 ha of chickpeas, 190,000 ha of faba beans, and 290,000 ha of peas, beans, and other food legumes. This would increase the share of pulses in total net arable area from 4.95 percent in 1989 to 6.7 percent by 2000, in a situation where rainfed land expansion has pretty well reached its limit in many WANA countries. <u>Given the competing pressures for available land from non-agricultural sectors; and within agriculture from rising needs of other food and industrial crops, and fodder crops</u>

<u>for livestock (also mainly legumes), and also for conversion of rainfed to irrigated land (where food legumes are currently at a yield disadvantage), this presents a massive challenge to the ICARDA food legumes programme, as well as to the limited staff of national food legume programmes in the region</u>. It is further complicated by a situation where wheat yields, having increased rapidly in the 1970's, are slowing down significantly, and the rate of growth of adoption of higher yielding varieties and fertilizer is also slowing down.

Since wheat, and barley (in which little yield improvement has occurred) occupy 50-60 percent of total arable area in the region this will put pressure on land for other crops, including food legumes. <u>How can this challenge be met</u>? The succeeding section will examine some of the issues and options, looking in more detail at recent trends in the region on a case-study basis.

4.2. <u>Opportunities for increasing food legume output in the WANA region</u>

There are five main options for increasing agricultural output, these are:

i. Expanding the net area cultivated by bringing new land into use.
ii. Increasing yields through technological change.
iii. Increasing cropping intensities and changing the enterprise-mix
iv. Developing sustainable integrated land use systems.
vi Increasing water use efficiency, which ought to be a major goal of improved technologlogies and changes in farming systems in the WANA region, where water deficiency is the main limiting factor to increased productivity.

Looking at these options we conclude:

i. <u>There is little opportunity for adding new cultivated land to rainfed area in the WANA region in the future</u>; more likely it will decrease somewhat from its present almost static level. Rainfed land will be lost to other sectors, roads buildings etc.. and to irrigation, while marginal arable land in low rainfall areas, on steep slopes, and in fragile soils should revert to tree crop cultivation, forest, or pasture.

It should be noted however that although the total net arable area is inelastic, it use over time, and also in any given year is fungible. Winter cereal area for example, which dominates rainfed land use in most countries, can vary by 30% from one year to the next, and, as Table 13 shows, the variability of lentil and chickpea area is generally higher than that of wheat and barley, although the area affected is much smaller**. Thus although there is scope for increasing the area under food legumes, forage legumes, or other rainfed crops; this will normally be at the expense of someother enterprise. With the exception of lentils in ecozones where rainfall is between 250 and 350 mm and soils have reasonable moisture holding capacity, or forage legumes and sown pastures in similar low rainfall zones, this situation is only likely to arise in regions of more favorable precipitation. If cool season food legumes (lentils, chickpeas, faba beans, or peas) are to hold their own or to increase their share of net cultivated area, their yields and costs of production and/or their prices, will have to compare favorably with a fairly wide range of alternative crops where rainfall exceeds 500 mm and temperature is not limiting, principally wheat, forage crops, vegetables, and annual oilseeds. In intermediate rainfall zones (350-500 mm), wheat, barley, forage and oilseeds will be the main competitors. In lower rainfall ecozones >350 mm. lentils will be competing for land mainly with barley and to a lesser extent with forage and pasture legumes.

ii. <u>The competitive power of food legumes with other crops in a situation where the land constraint is likely to become increasingly severe depends heavily on improving their productivity per unit of area and time and/or on reducing their costs of production, preferably both. This implies technological</u>

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* The area sown to cereals in any given year depends significantly on the timing and amplitude of the first rains. If these are good the area sown is likely to be larger than in years of low or delayed initial rains. When the early sown cereal area is large, that under food legumes may be reduced; when rains are late and the ceral area is smaller the area under spring or late winter sown lentils and chickpea may increase.

change. Various studies of comparative advantage-for example by the World Bank in Syria and Turkey, show that at current prices and costs financial and economic returns from food legumes are somewhat above those of cereals and annual oilseeds, but well below those of fruit, olives, vegetables, and melons.

Given the differences in market demand and capacity to absorb different products there may always be a place for a limited area of food legumes on farms for home consumption or local sale, even in favorable rainfall areas where crops of higher value but more difficult marketing and storage problems can be grown, especially where price support policies for legumes are in force.

However, unless food legumes can be adapted to produce at higher yield levels under irrigation or to fit special ecological niches in higher rainfall zones (perhaps being cultivated between rows of fruit trees or olives); their main partners in farming systems, and also their main competitors where land is scarce seem likely to be wheat, oilseeds, and annual forages in the 350-500 mm rainfall zones, or wheat, barley, and forages below 350 mm. ICARDA and other studies (Oram 1988), indicate that crop diversity is greater in zones with rainfall exceeding 400 mm, fallow area decreases, the area under fruit and nut trees and summer vegetables increases, and the share of livestock in farm income falls. Three-course rotations are common, and chickpeas, faba beans, or forage species are the predominant legumes. Below 400 mm diversity is lower, two course rotations are more common, including a higher proportion of cereals and fallow, while lentils are the main legume.

These studies suggest that it may be important to target research on food legume yield improvement to the needs of specific ecozones and the farming systems and alternative crops which predominate in those zones and farming systems. Even broad problems which appear to cut across zones such as weed competition, Ascochyta blight, mechanization of harvesting etc are likely to vary in intensity and nature among different ecozones. The same should apply to forage and pasture legumes. This would help considerably in setting research priorities and allocating resources to research, as well as in providing more precise guidance and locationally appropriate cultivars etc. to extension services.

Little progress has been made until recently in raising average yields of food legumes, for reasons which are not only related to lack of adequate research effort in the past (and even now in many national systems), but also to poor targetting of extension effort and inadequate seed production capacity when improved cultivars have become available.

iii. A main source of growth of food legume area in the WANA region in recent years has been the substitution of the cereal-fallow system by continuous cropping of other crops in rotation with cereals, principally wheat; in other words by increasing cropping intensities. Obstacles to this in the past have been:

a. The wheat national self sufficiency syndrome, leading to high support prices and input subsides which have favoured wheat over other rainfed crops, including barley and all types of legumes.

b. Lack of power to till and harvest a larger crop area each year.

c. Perceptions of high benefits accruing to wheat yields from fallow, which would be reduced in a continuous cropping system. The fallow is theoretically maintained to restore soil fertility to the next cereal crop, to store water and to control weeds; but in fact, if not cultivated, it may do none of these things. Nevertheless it provides a break from the cereal which may reduce disease build up, and the weeds can provide useful grazing for sheep.

e. Failure to recognize that the area idled under fallow was a potential source of income (other than for ad hoc livestock grazing), due partly to unquestioning acceptance by many agricultural scientists of its benefits to the wheat crop, and a consequent lack of research to characterize ecological situations where alternative systems of land use would be both more profitable and sustainable.

This situation has changed significantly in the 1980's, with the area of fallow being reduced substantially in many countries and replaced by continuous cultivation. Up to the mid 1970's fallow was generally 40 to 50 percent of total rainfed arable area (excluding permanent crops) in much of the region; it has been reduced progressively, and at an increasing rate since then.

This is partly because of population pressure on land resources to produce more food, both for self consumption by farm families and for urban consumers; partly because mechanization has enabled farmers to sow and harvest more land each year; and partly because of increased demand for livestock feed. Statistics on the area of fallow are poor, but recent estimates of the overall proportion of annual cropped area fallowed in 1987, in Syria, Tunisia and Turkey indicate that it is now about 27, 26, and 31 percent respectively in the three countries (Oram 1989). In the higher rainfall ecozones it is lower: about 12 percent in zone IA of N.W. Syria, 20 percent in Northern Tunisia, and under 15 percent in the Mediterranean and Black Sea ecozones of Turkey.

Studies in Turkey indicate that fallow is not necessary there where the soil depth is less than 90 cm in areas where rainfall exceeds 320 mm, even if fallow is currently being practiced there (Guler and Karaca 1988). This conclusion is based on the assumption that moisture conservation for the cereal crop is the main goal of fallow, rather than increasing nitrogen content or improving soil structure. The results are based on the use of an index including annual rainfall, and average annual temperature for the months exceeding $0^{o}C$, to delineate the fallow boundary, using data from 500 meterological stations all over Turkey. The area which could be taken out of fallow using this index is huge, covering most of the Anatolian plateau. It would reduce by half the overall area of fallow in Turkey, estimated at over 8 million ha in 1980 (33% of total arable area).

<u>Experimental results and studies of farm practices in the main</u>

<u>regions where fallow could be reduced indicate that food legumes, and in some areas fodder legumes, or sown pastures in cold, high elevation areas of Eastern Anatolian are the optimum crops to cultivated in two year rotations with wheat</u>.

It is important to note that while conditions in Anatolia are not typical of the lower altitude zones of Turkey where fallow is already much reduced, the methodology and approach could be valuable in determining the areas and ecozones in other countries of the region where land use intensity could be increased on a sustainable basis by the elimination of a proportion of the fallow. It is also note worthy that according to Kassam (1988), about 21 percent of the land area in West Asia, and 8 percent of that in North Africa is at altitudes above 1500 mm where conditions more comparable to those in central and northern Turkey exist, including winter rainfall areas of temperate northern China and most of Korea which are similar to N.W. and N.E. Turkey and N.W. Iran. The area of high elevation land in Eastern Asia is very large, currently about 20 million ha, and food legumes, especially faba beans and peas, but also chickpeas and lentils, are very important there. It is planned to expand the present area of about 2 million ha of food legumes in the plateau areas of north and north west China considerably, with the objective of rainsing <u>per capita</u> consumption from its 1982 level of 5.4 kg p.a. to 18 kg by the year 2000. (Hu Jiapeng 1988). ICARDA varieties have been found to be drought resistant, well adapted, and with great production potential there: creating good opportunities for increased ICARDA collaboration with Chinese scientists.

The current annual cropping intensities in rainfed agriculture in the WANA region are low in both rainfed and irrigated land (averaging about 0.65 and 1.30 respectively). The main cause of low intensities in rainfed land is the fallow practice; there is a number of reasons for low intensity in irrigated land, leading to some land being fallowed, such as irregular water supply and salinity but they are not the same as those determining rainfed fallow.

As population and incomes rise it will be imperative to use land more intensively, and in many instances this will mean reducing fallow, changing farming systems, and altering the enterprise-mix. This creates great opportunities for increasing the share of cool season legumes, both for food and forage in rainfed farming systems; especially in the middle rainfall and drier zones, and in these with colder winters; where opportunities for production of potatoes, vegetables, annual oilseeds, warm-season legumes and industrial crops are constrained by climate and in some areas by soils with limited moisture-holding capacity.

We consider that this constitutes a major case for maintaining a strong cool-season legume research effort at ICARDA, which is the only existing institution capable of working across countries, not only in the ICARDA region, but through direct collaboration or networks reaching out to countries with analagous ecological conditions outside its borders, such as India, Nepal, China and Korea. Lentils must be a key component of this effort even if they do not occupy the largest share of food legume area, since they are the food legume ecologically best adapted to cultivation in the lower rainfall and higher altitude ecozones and have value both for grain and for forage.

Intensifying land use in rainfed areas can be achieved in several ways, e.g.:

i. Shortening the growing season of main crops, to allow double-cropping. This is only likely to be feasible in the WANA region where there is summer rainfall or irrigation.
ii. Substituting an annual crop for fallow in the rotation.
iii. Introducing livestock into the farming system, based on the cultivation of annual or perennial forage crops and by-products e.g. lentil straw.
iv. Planting tree crops which occupy the land year-round; this technically raises land use intensity to 100.

These approaches may be complementary or conflicting, depending on the strategy adopted. Raising the yields of the key crop in the rotation may be difficult if this depends on a long growing season and introducing a second crop in the same year reduces that time, or if it depletes soil moisture or fertility. Switching from cereal-fallow to continuous cropping in alternate years may also affect cereal yields. Thus it is essential to evaluate the trade-offs in terms of net product value rather than volume, across the rotation over time, both in financial and economic terms. The result is likely to differ with the commodity composition of the cropping system, and the ecology of the area.

As indicated above, the area of fallow is now quite low in the ecologically advantaged regions, but this does not preclude shifts in the cropping system towards more valuable commodities than cereals, for example early vegetables, fruits, tobacco, oil seeds, pulses, and forage crops for livestock. In addition to having higher income elasticities of demand than cereals, several of these commodities provide a basis for processing industries as well as for fresh exports. However, they also tend to have higher labour requirements than cereals and thus may face greater competition for labour from industry, services, and tourism; especially as the ecozones in which they can be produced also tend to be those where the main cities and industries as well as the major tourist attractions are located. Labour costs and availability are emerging as a major constraint to diversification away from cereals.

Outside these higher rainfall zones there are ecozones of drier and colder climate with a much larger proportion of fallow in a mainly cereal-fallow cropping system. Diversification is more difficult in these ecozones, nevertheless, as recent developments have shown, there may still be scope for change. The most striking example is from Turkey, where the government, with World Bank assistance, has made more effective use of fallow land a major development objective. In the late 1970s a pilot program was launched in northern Anatolia to substitute improved food legume varieties of chickpeas and lentils, and winter forage legumes (Hungarian vetch - V. pannonica) for fallow and unimproved varieties of food legumes and spring-sown vetch. This campaign, which also involved increased use of inputs, mechanization, and supporting credit, was so successful that in about 5 years a cereal-legume rotation had superceded the traditional cereal-fallow system over a high proportion of the project area. This was a region of intermediate rainfall (450-390 mm average) but with average monthly temperatures above 0°C throughout the year. Fallow represented 40-50 percent of the arable cropped area.

Following this success a larger project involving a major research and extension effort was launched which aimed to answer two important questions. These were:

- Under which ecological conditions can fallow safely be eliminated?
- What are the most suitable and/or profitable crop rotations?

As a result of agro-ecological surveys and analysis of research data, with special attention to precipitation and soil moisture holding characteristics, as well as studies of farmer's practices and crop combinations it was decided that around 3 mill ha of fallow land could be used for cropping with food and forage legumes in rotations with wheat or barley, and a two-phase project was established to cover the period 1982-91, with research and extension backed by credit for seed and fertilizer as well as by price support for leguminous crops.

The result has been to reduce the area under fallow by 22 percent by 1986 in the project area, and by an even larger amount in other areas of the country to which the practice has spread. This has resulted in an overall decrease in fallow area of 33 percent between 1979 and 1986. The impact on food legume production has been even more dramatic: chickpea area grew at an annual rate of 15.9% between 1980 and 1986, and that of lentil by 24.7%: four and three times the 1970-79 growth rates, which themselves were quite high. The area of vetch for forage increased by 12% annually, ten times the 1970-79 level. Yields of the legumes did not appreciate much, so that the increase in area is about synonymous with that of production. The latter rose from 408,000 tones in 1979 to 1.48 million in 1986: almost a fourfold increase in seven years. Production of other food legumes such as Faba bean and haricot bean has also accelerated rapidly over the same period.

The striking success of the Turkish campaign both offers hope to other WANA countries striving to increase production of food crops other than cereals from a finite total area of available land, and poses some interesting questions. It would be valuable to know, for example:

1. The extent to which improved legume technology contributed to the project. One Turkish paper (Duratan et. al. 1988) states that research was undertaken on chickpea and lentil breeding, but our discussions with key food researchers in central and S.E. Anatolia (two of the main food legume producing regions), indicate that although progress has been made in improving yields, especially of chickpeas, and that some improved chickpea and lentil cultivars have been released, this has occurred fairly recently. Thus new varieties probably did not contribute much to the campaign outlined above. Significant problems restricting food legume yields remain to be solved especially related to cold tolerance and serious weed competition in fall sown lentils and vetches for Turkey, but also in all other WANA countries. These problems are discussed in more detail later in this report.

   However research was also undertaken on crop management, building for example, on earlier work in Turkey on crop rotations and moisture conservation. This may have contributed most to the immediate success of the project, while the breeding programme may be expected to provide continuing impetus over the longer term.

2. What application might this research on crop management and rotations have to other countries of the region, especially in relation to the controversial issues of the value of fallow in different soil and climatic conditions and the optimum combinations of other crops with cereals in place of fallow. Turkish experience seems to indicate that while all grain crops depress cereal yields somewhat compared to fallow, legumes are the most suitable companion crop to the cereal in terms of water use efficiency and ammonium and

nitrate nitrogen, and that non-legume crops (Safflower, sunflower, continuous cereal) tend to reduce soil moisture and nitrogen more than legumes, resulting in larger reductions in yields of the wheat in a two year rotation compared to fallow. Spring sown legumes have higher yield variability than fall-sown ones, since they depend on a shorter rainy period, and they also tend to reduce wheat yields more.

Seedbed preparation and tillage to ensure good plant establishment, and weed control were the two priority components of the crop management package. Weed control is particularly crucial for winter planted crops and crops grown for grain rather than forage. Leaving crops weedy reduced lentil yields by 21% and those of vetch by 29-48%. Failure to control weeds has cumulative effects.

These results, although obtained under a better and more stable rainfall regime than in many other WANA countries broadly confirm results of field trials in Syria, Tunisia, Morocco and Algeria, while still leaving some long standing controversial issues open. e.g. the merit of deep of tillage, optimum tillage implements for different crops and soils, and seeding methods. These issues are likely to be of greater significance where rainfall is lower and more available, since the Turkish work shows clearly that differences among various rotation systems in terms of their impact on wheat yields as a result of moisture depletion fade out progressively as annual precipitation exceeds 400-500 mm. Whether this applies more generally remains to be tested we shall discuss these issues in more detail later in this section.

Most of the Turkish research has focused on two course rotations in Anatolia. This is probably relevant to much of the area suited to fallow replacement in other countries i.e. in the 300-450 mm rainfall belt, but may not provide useful guidelines to optimum cropping systems in wetter and warmer, <u>or</u> drier and warmer ecozones of West Asia and North Africa, nor in India or Pakistan, where chickpeas and lentils are grown under different ecological conditions, often with residual moisture on land left fallow after the rice crop in the case of lentil, and sometimes intercropped with wheat. The one year fallow, one year wheat production is not common in those countries.

3. How much has the special effort to promote the new system, with strong government as well as World Bank support, enhanced its success? What were the main institutional components of that success, research, extension, credit, marketing, government or private enterprise? The research system in Turkey is disjointed, despite recent recognization, and weak research-extension linkages there have been criticized. Yet in this case everyone appears to have cooperated effectively, even to the extent of generating a large "spillover" effect to neighboring regions of Turkey not covered by the project. How was this achieved?

4. How far did the price support given to food legumes and/or increases in their prices relative to wheat or barley contribute to their widespread adoption? In most other WANA countries cereal prices are supported but not those of food legumes.

   At constant prices the situation has shifted significantly in favour of grain legumes in Turkey since 1970; green lentil and chickpea prices in 1984/86 were about 3 3/4 times those of soft wheat and red lentil over 4 1/3 times. Cereal yields have risen 40% since 1970, while food legume yields have stagnated, but when the price changes over time are compared to yield increases over the same period it can be seen that the yield advantage of cereals over legumes in 1984/86 is quite small compared to the price advantage in favour of the legumes. Thus unless there is a very great difference in production costs the legumes are clearly an attractive proposition in Turkey.

   World Bank studies there indicate that legume production costs are higher than these of cereals, but not enough to offset their price advantage. This ought to be the case also for chickpea in Northern Tunisia, where a similar price/yield relationship with cereals exists.

In Northern Syria an ICARDA study, Nordblom (1987) shows that production costs of lentil are about 80% higher than those of wheat and 43% above those of barley, mainly related to higher costs of weed control and harvest labour. This confirms the need for research on herbicides and mechanized harvesting of food legumes. However at 1985 prices a combination of wheat and lentils was the most rewarding rainfed system of ten systems under trial when measured in financial returns. Recent lentil grain price increases and high straw value in Syria probably account for the very large increase in their area there in 1989, but there may be other rseasons too, and these merit attention by ICARDA.

5. Does the overall <u>net</u> financial return from the cereal food legume system in Turkey exceed that from cereal fallow, or cereal-forage legume?. In the latter case there may be options to feed the forage to land-owners' animals, green or as hay or silage; to rent the land under summer fallow plus the forage in late winter and spring for grazing; or to cut the forage for hay and sell it. Good legume straw is currently reported to be fetching high prices in Syria, Tunisia, Morocco: even baled barley straw commands prices up to 60% of the grain value. This also has to be taken into account in assessing net profit from the whole system. We give an example in the next section of this paper.

   Such calculations ought also to take account of any saving in Nitrogen fertilizer application to the cereal as a result of the nitrogen fixed by the legume, although as mentioned earlier, this may not be large if the legume is harvested for grain. If the cereal or the legume is grazed, an additional contribution to soil fertility and organic matter content could be expected from animal manure.

6. What has driven up the demand for food legumes so fast in Turkey? It has been suggested that this may be a consequence of an

inflationary growth of prices of livestock products, which has pushed them out of reach of the less affluent consumers, leading to a reversion to vegetable sources of protein. Meat prices are also reported to have risen sharply in several other WANA countries; what effect will this have on the relative demand for food legumes fodder legumes, and for barley for animal feed, and what will be the implications for future land use*?

7. If there is a net <u>financial</u> gain from the inclusion of a legume in the continuous cropping system (whether for grain or forage) then the farmer is likely to adopt it in place of the traditional cereal-fallow, unless there are structural obstacles, as with the medic increased livestock system.

However, from an <u>economic</u> point of view, the widespread adoption of a legume-based system which reduced cereal yields, even it increased farmer's incomes, could lead to a reduction in availability of cereals at the national level, requiring increased cereal imports, or reducing cereal exports.

In the Turkish case cereal yield has increased by 5% and production by 8% (2.1 million tones) between 1979/81 and 1984/86; food legume production by 300% and exports of lentils and chickpeas by about the same order of magnitude.

Thus, unless there were distortions due to subsidies on production or exports, there have clearly been significant gains to the economy from the replacement of fallow by food legumes. Price comparisons for 1988 between f.o.b. prices of Turkish and U.S./Canadian lentils do not suggest any international export price disparities, or subsidies to Turkish food legume exports, despite recent statements in a Canadian trade journal to this effect.

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* It is reported from Algeria that for the current price of one kilogram of meat it is possible to buy 25 kgs of lentils in local markets.

This situation may be exceptional because of Turkey's very large land resource and good ecology for lentil and chickpea production, but it is a striking illustration of the latent potential for reduction of fallow and diversification of rainfed land use systems, in the WANA region, which suggests that this approach merits high priority in other WANA countries. The role of the legumes, whether for food or for forage is likely to be pre-eminent in any such developments.

Forage as such is not an exportable commodity, but if an increase in domestic forage production increased meat,milk, and wool production from ruminants, it could either reduce imports of livestock products and animal feed or generate livestock exports, for which some WANA countries appear to have a comparative advantage,at least in intra-regional trade.

Analysis by ICARDA of the factors which have contributed to Turkey's success in introducing food legumes into rainfed cropping systems in place of fallow, as well as of other successful national achievements in this respect either related to food or forage legumes, would be valuable both to ICARDA's own scientists, and to other countries in the region still struggling to expand and diversify rainfed agricultural production. Even if a main reason in Turkey's case is the special ecological situation in the upland areas, the approach might still be replicable in Iran, northern Iraq, northern Pakistan, Nepal, Mexico, Ethiopia and parts of Algeria and Morocco. If the secret lies mainly in technical achievement, in economic incentives, market development, or a good extension campaign it could be more widely replaceable throughout the region.

There are clearly valuable lessons to be learned from such an analysis, since the more effective use of the fallow is the principal major avenue remaining open to increasing rainfed land use intensity and diversifying the arable land use pattern to exploit comparative advantage in the majority of WANA countries.

4.3. <u>The potential for reduction in fallow</u>

Several efforts have been made in the past to estimate the total area of land in WANA where fallow might be replaced by other crops. The usual assumption has been that these would be principally food or fodder legumes. For example Carter (1978) assumed that total fallow area in nine countries of WANA was about 30 million ha in 1975/76, based on FAO data. Of this he estimated that there was a potential for planting 23 million ha (about three quarters), with food or forage legumes or legume based pastures. It is interesting to note that for Syria, Tunisia and Turkey he calculates that the introduction of legumes into the system would provide 672,000 tons of Nitrogen to the soil, whereas the actual increase in Nitrogen fertilizer use by farmers in those countries since 1975/76 has been very close to that increment. However his assumption that three quarters of the fallow could be cropped seems too high, since recent data for the three countries mentioned above indicates that the fallow area has declined from 13 mill ha in 1975 to 8.5 mill ha by 1988-a reduction of only 35 percent compared to his estimate for them of 86 percent.

Another and more conservative estimate was made by Leeuwrik (1975), who postulates that approximately 2.9 million ha of fallow in six WANA countries could be sown to legume pastures. His calculation includes Morocco and the Lebanon, which Carter's does not, but does not include the three West Asia countries with large areas at higher elevations which are in Carter's estimate (Afghanistan, Iran and Turkey). Based on these estimates, and actual progress since 1975 in Syria, Tunisia and Turkey, it seems likely that about 12 million ha of fallow have been brought into continuous cropping in eleven WANA countries between 1975 and 1989, including Afghanistan, Iran, Jordan, the Lebanon, Syria, and Turkey in West Asia, and Algeria, Morocco, Tunisia and Libya in N. Africa. This would leave about another 12 million of potential fallow according to Carter's estimate, of which perhaps six million might be brought into continuous cropping by the year 2000. Our discussions in Syria, Tunisia and Turkey suggest that 2 million ha of this area might be in Turkey, 625,000 ha in Syria, and 275,000 ha in Tunisia, leaving a balance of about 3 million ha for the other eight countries. In Algeria the current fallow area averages around 1.6-1.7 mill ha, and it is about 2.1-2.3 mill ha in Morocco, although fluctuating from year to year according to annual precipitation and the consequent influence on the area sown to cereals. About 1.32 mil ha (550,000 ha in Algeria and 770,000 ha in Morocco), might be brought into continuous cultivation there, and it seems probable that most of the remaining potential (approximating to 2 mill ha) would be in Iran and Iraq.

Much of the limited remaining fallow area in other countries such as Libya and Jordan is in low rainfall areas, there is no scope in Egypt or the Northern Sudan, where all arable land is irrigated, and very little in the Arabian Peninsula. The bulk of arable land in Pakistan is irrigated. Barrani areas of Northern Pakistan are heavily cultivated, and much of Baluchistan is too dry. In any case not all of the fallow in any country can be replaced by continuous cropping, even in the countries with substantial rainfed land; much is too dry, and where soils are deep enough to store moisture, fallow may be essential to support even one cereal crop in two years; some areas are too cold, some are too steep, and some suffer drainage problems.

Bringing another six million ha of fallow into crop would increase the gross cropped area by about 9 percent on average in Syria, Turkey, and Tunisia (12.5 percent in Syria, 9.5 percent in Tunisia, and 8 percent in Turkey). For the average of the eleven countries mentioned above the impact would be much the same, about 8.6 percent overall.

This additional arable land could either be used for food legumes, fodder legumes, barley, annual oilseeds or sown legume-based pastures. It is unlikely to be used for wheat, sugar beet or cotton, but in the higher rainfall ecozones, especially where winters are mild, some fallow land might also be used for potatoes (a rapidly increasing crop), vegetables, or reserved for an early summer crop such as melons or water-melons. This would probably be in a three-crop system (ICARDA 1986). In areas where topography is less suited to annual cropping, some land currently idle or used for grazing might be planted to fruit tress, almonds, or olives.

At present much of the fallow which has been brought into continuous cropping has been in ecozones of higher or more stable rainfall in the 350-500 mm rainfall spectrum, often with either food or forage legumes as the main alternative to fallow in rotation with wheat. Very little land has so far been taken up by sown legume pastures. In some areas in this rainfall spectrum sunflowers are beginning to enter the system, but with considerably greater effects on depleting soil moisture*. In lower rainfall (250-350 mm) areas some land has gone into lentils, but probably more into barley for sale or for livestock feed on farms where sheep form an integrated part of the system. The area under continuous barley is expanding in the drier ecozones, and extending to marginal areas which probably should never be cropped.

While it seems probable that in the future annual food and fodder legumes will continue to be the main alternative to wheat in continuous cropping systems in the more favorable ecozones, an important issue centers on what will be the alternative in lower rainfall regions given the importance of small ruminant livestock in the farming pattern there. At higher elevations where rainfall variability is relatively low, either lentils, annual or perennial forages, or sown legume pastures seem feasible options to cereals; but in drier lowland regions where temperatures are higher and rainfall is extremely erratic , barley is often the crop of last resort.

ICARDA's studies of the role of barley in Syrian agriculture (Mazid and Gallajian) show that in drier ecozones it is considered by many farmers to be their most important activity, nearly 75 percent in zones 2, 3, and 4 (rainfall 250-350 mm, or < 200 mm in one out of two years), cite barley as the crop using most land. This is partly because many of them also rate sheep as a key enterprise, and partly

* 1988 FAO data show 760,000 ha of sunflowers in Turkey, 52,000 ha in Morocco, 25,000 ha in Iran, 16,000 ha in Syria, and 13,000 ha in Iraq. Some of this may be irrigated.

because barley is such a flexible crop; the grain can be sold or fed to livestock, the green crop can be grazed in winter and then allowed to mature for grain, the straw is considered valuable for feed, and in a bad year (like 1988/89) the whole mature crop can be grazed instead of being harvested for grain. A similar situation prevails in the Centre-South of Tunisia.

How to develop viable alternatives to continuous barley in these zones poses difficult issues for research, since while it can be shown experimentally that continuous barley is likely to be an unsustainable system in the long run, with a high probability of declining profit margins due to disease build up and deteriorating soil fertility, it is not proving easy to find suitable alternative legume based systems (such as Medic based pastures) which are financially and ecologically superior, and which fit well with the structural and social environment of WANA. This poses a major challenge to ICARDA, since a higher proportion of future fallow cropped land is likely to be in less favorable environments, and it is an issue which cuts across its legume, cereal, and farm resource management programmes.

4.4. The contribution of legumes to sustainable farming systems

In dry environments, inadequate moisture is the principal factor limiting rainfed agriculture. Low, unreliable and unevenly distributed rainfall causes high production variability in the WANA region. Low soil water budgets have usually limited annual cropping* thereby leading to a widespread utilization of the fallow-cereal cropping system (in the region, the fallow area currently ranges between 30-45% of total rainfed cultivable area). The limited land resource base has forced policymakers to undertake fallow reduction programs in order to reduce increasing food deficits and to fulfill food security objectives. Therefore, projects aimed at replacing the traditional fallow-cereal crop sequence by a legume-cereal sequence have been initiated throughout the region.

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* Continuous cereal cropping, e.g. wheat-wheat, barley-barley and wheat-barley is excluded from this denomination.

Given the variable nature of WANA environments, a question, that has not yet received an unequivocal answer, has been raised concerning the effect of annual cropping on the sustainability of the production system. This focuses particularly on the effect of annual cropping on soil water and soil nitrogen budgets. Decisions to introduce legumes or other annual crops to in to the rotation, in order to reduce fallow and/or to break continuous cereal cropping, are therefore, tied to their potential effect on soil water and nitrogen balances, i.e. on the sustainability of the production system. This is by no means an easy task as many other factors are also part of the production equation. Nevertheless, bearing in mind the complex aspect of the question, the beneficial effects of legumes on the cropping system can be assessed in terms of water and nitrogen balance in comparison with fallow and wheat and/or barley.

4.4.1. Crop water use

The use of fallow for water storage purposes has been widely advocated in rainfed agriculture in various regions of the world, e.g. Pacific Northwest of the United States. In the WANA region, the fallow-Cereal cropping system is also widespread. The water stored during the fallow year adds to the following year's precipitation and thus leads to higher yields (because of no or low moisture stress) of the subsequent crop, i.e. the cereal, in the rotation. However, the environmental characteristics of some regions, i.e. high spring and summer temperatures, relatively light and shallow soils with low holding capacity, etc, can reduce considerably the moisture storage benefit of fallow.

In a long-term rotation study in Syria, Harris (1988) has found that by the beginning of the cereal season, less than 10% of the rain which fell during the fallow season remains in the soil profile, implying a low fallow efficiency. Guler and Karaca (1988) have also indicated that, in Turkey, fallowing is not beneficial, in soils of less than 90 cm depth, because the amount of water stored is too low to be of any economic value. The results of a long-term rotation study conducted in Turkey (Karaca, et al., 1989) confirms the previous findings. It indicates that moisture stored, at 120 cm depth, after fallow was only 11 and 15% higher than moisture stored after hungarian vetch and winter lentils, respectively (Table 14).

The results of the Turkish study also show that, except with safflower-wheat and wheat-wheat rotations, the succeeding wheat crop had a higher water use efficiency (WUE) to that of wheat after fallow. A higher WUE was obtained in the barley - forage legume rotation than in the fallow - barley rotation in the Syrian study (Harris, 1988 op cit). Based on the results of the Syrian study, She (Harris) concludes that "... it should be biologically feasible to replace fallows with a legume to both increase the productivity of the system and to sustain production in the long run".

Podimatas (1988) also indicated that forage and food legumes were widely introduced into rotations with wheat and other cereals in Greece in the 1960's as a result of their superiority to cereal mono-cropping. Legume superiority was demonstrated through long term rotation trials which started as early as 1937 at the Fodder crops and Pastures Institute in Larissa, Greece.

More carefully monitored long-term rotation studies are, however, needed in the region in order to avoid making linear extrapolations which do no take sufficient account of the peculiarities of different cropping environments.

The yield of the succeeding cereal crop has been (still is) a common measure for evaluating the potential effect of a given crop preceding the cereal in the rotation. Obviously, this method fails to take into account the returns derived from the first phase of the rotation when a crop, instead of fallow, precedes the cereal crop. Therefore, when estimating the benefits of various crop rotations, it is necessary to account for the returns of each crop during each phase of the rotation.

Table 14. Effect of 2 years rotation systems on succeeding wheat, Turkey 1983-88.

Rotation	Crop yield Kg/ha	Et for crop mm	WUE of crops kg/ha mm	Soil moisture mm/120 cm	Moisture storage efficiency %	Wheat yield kg/ha	Yield loss %	ET for wheat mm	WUE of wheat kg/ha mm	WUE comparison to fallow %
Sunflower - wheat	840	354 ab	2.0 cd	203 d	- 5.2	2910 d	14.7	320 cd	9.5 abc	+ 6.7
Winter lentil - wheat	1050	310 cd	3.7 bcd	245 bc	7.8	3190 bc	6.5	358 b	9.8 ab	+ 10.1
Spring lentil - wheat	940	346 b	2.9 cd	210 d	- 2.6	3040 cd	10.9	329 c	10.0 a	+ 12.4
H.vetch - wheat	1860	299 d	6.4 a	255 b	9.8	3300 ab	3.2	366 b	9.7 ab	+ 9.0
Safflower - wheat	1020	369 a	2.7 cd	191 e	- 9.2	2500 e	26.7	309 d	8.3 c	- 6.7
Wheat - wheat	1760	345 b	5.7 ab	209 d	- 2.2	1890 f	44.6	326 c	6.4 d	- 28.1
Cumin - wheat	530	322 c	1.7 d	235 c	3.8	3140 bc	7.9	355 b	9.3 abc	+ 4.5
Chickpea - wheat	1120	348 b	4.0 bc	209 d	- 3.4	3180 bc	6.7	326 c	10.2 a	+ 14.6
Fallow - wheat	-	-	-	284 a	19.4	3410 a	0.0	399 a	8.9 bc	0.0
P	-	0.01	0.0.1	0.01	-	0.01	-	0.01	0.01	-
LSD (% 5)	-	15	2.0	10	-	168	-	13	1.2	-

Probability (P) of no difference does not exceed indicated value, Efficiency (%) = net gain soil water cm/precipitation, cm) x 100, ET = net gain soil water, cm + precipitation, cm WUE = yield/ET.

Source: Karaca et al. 1989.

Very few rotation studies include an economic evaluation of the results. The farmer's objective is not to increase moisture storage efficiency, per se, but rather to maximize expected net returns, with due allowance to risk and uncertainty. There is evidence that even short run profits are higher with legume-cereal rotation than with fallow-cereal or cereal-cereal rotations. Nordblom (1987) has indicated that a two-course lentil-wheat rotation had the highest overall present value of seven rotations studied. In addition, the inclusion of legumes in the rotation does not negatively affect, the sustainability of the production system, but tends to increase it.

Conclusions of the type "wheat yield after fallow is X% higher than wheat yield after a legume", for example, are very common. A single partial budget will show, however, that the net returns derived from the crop preceeding wheat more than offset the yield discrepancy usually reported.

For the sake of demonstration, the results of the rotation study reported by Karaca, et al (1989) are used to illustrate this point. Gross returns are evaluated for five crop sequences*: winter lentils - wheat; spring lentils - wheat; chickpeas - wheat; wheat-wheat and fallow-wheat. A four-year period is used so that each crop, including fallow, will appear twice in the calculations, thus taking into account any variability over time. Since the type of lentils grown (green or red) was not specified in the study, an average price was used in the calculations. Farmgate prices for the 1985-88 period are shown in Table 15.

In phase one of the sequence, the 1986 price is used for wheat, i.e. 79 TL/kg; 1985 prices for lentils and chickpeas. In phase two, the 1988 price is used for wheat (174 tl/kg) and 1987 prices for lentils and chickpeas (300 TL/kg). These prices were chosen in order to get conservative gross returns from the legumes .

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* The Hungarian vetch-wheat sequence is not included because vetch prices were not available.

Table 15. 1985-88 prices of wheat, chickpea and lentils in Turkey (TL/ha).

	1985	1986	1987	1988
Wheat	62.5	79	96.5	174
Lentils(1)	180	290	300	395
Chickpeas	185	290	300	460

(1) average price of red and green lentils.

Table 16. Gross returns derived from various rotation sequences with wheat 1985-88. TL/ha.

Rotation	Yield crop* Kg/ha	Gross Ret. Crop 1	Wheat yield* Kg/ha	Gross Ret. wheat	Total Gross returns**
Winter lentils-wheat	1050	189,000	3190	957,000	1,146,000
Spring lentils-wheat	950	171,000	3040	912,000	1,083,000
Wheat-wheat	1760	110,000	1890	182,000	292,000
Chickpeas-wheat	1120	207,200	3180	954,000	1,161,200
Fallow-wheat	-	-	3410	593,340	593,340

* Average yield over four cropping years, i.e. two seasons of legumes crops, or fallow, and two seasons of wheat.

** Average gross returns over the two year sequence, i.e, average gross returns per ha of crop plus average gross returns per hectare of wheat.

Source: Data from Karaca, et al. (1988).

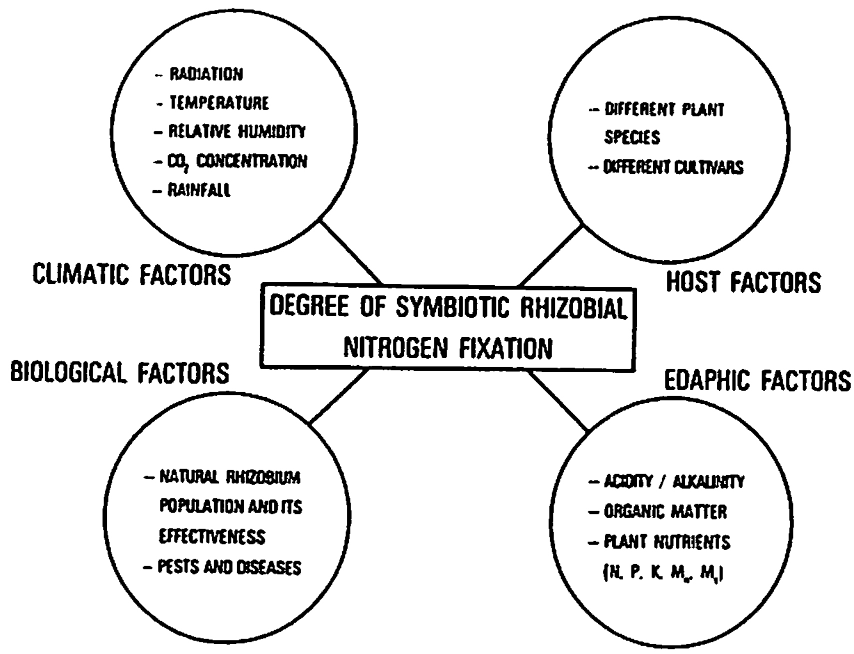
This simple exercise shows that although wheat yield following fallow was higher than wheat yield following legumes, gross returns from the legume - wheat rotations were way above those from fallow-wheat and, even more so, wheat-wheat rotations. As expected, gross returns from the wheat-wheat rotation are very low because of the depressing yield effect of continuous wheat cropping. The yield of one wheat crop after fallow, for example, is close to the sum of the wheat yield during two seasons of the wheat-wheat sequence (3410 kg/ha for wheat-fallow versus 3650 kg/ha for wheat-wheat). The extra gross returns generated by the legume-wheat sequence compared with the fallow-wheat sequence, over the two-year period, amount to an equivalent extra wheat yield of 3200 kg/ha.

This type of straightforward economic evaluation, if included in rotation studies, will further strengthen the case for introducing legumes in the rotation in replacement of fallow, and especially for breaking the continuous wheat cropping system.

4.4.2. Biological nitrogen fixation (BNF)

Another advantage of including legumes in the cropping system is their capacity to fix atmospheric nitrogen. Through this process, legumes play an important role in improving the sustainability of the cropping system. In nitrogen deficient environments, including a legume crop in the rotation improves the soil nitrogen budget, or at least lessens the amount of inorganic nitrogen input to the legume crop. The symbiotic nitrogen fixation by legumes is, therefore, considered as an important, and low cost, source of nitrogen added to the cropping system. However the biological nitrogen fixation process is quite complex. (Fig 1) The amount of nitrogen fixation by legumes is largely controlled by plant photosynthesis which is affected by agroecological as well as genotypic factors.

Fig. 1. Various environmental factors affecting symbiotic nitrogen fixation.



Source: Islam, 1979.

One such factor affecting BNF is the degree of effectiveness of the rhizobia synthesis with the legume plant. Inoculation may be used in case of low rhizobium efficiency. The same rhizobia is usually effective on faba beans, lentils and peas. Since these species have been grown for quite sometime in the region, the natural supply of effective rhizobia is usually satisfactory, thus inoculation is often not required. In lentils, however, rhizobium efficiency may be considerably affected by Sitona damage. The sitona larvae feeds in the nodules thereby affecting the nitrogen fixation ability of the lentil plants. Studies on control methods of sitona and economic evaluation of the control, have been undertaken by ICARDA. The results show that sitona damage is significantly reduced by carbofuran applications. So far, however, a very low correlation between nodule damage and yield has been found (Weigand, 1987). The low yield response to sitona control suggests that some other factor may be more limiting then sitona damage.

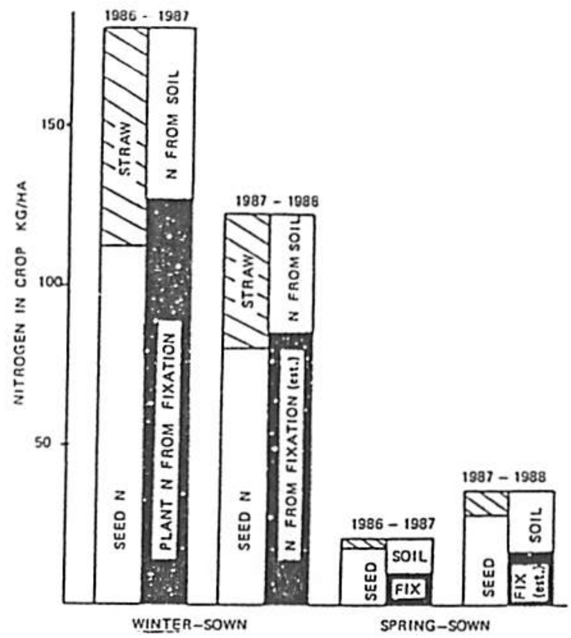
Chickpeas require a specific rhizobium strain. Symbiotic deficiency has been reported on chickpea plants newly introduced to areas where they were not previously grown, e.g. case of winter chickpeas. Inoculation with the appropriate rhizobium strain improves symbiotic efficiency of chickpeas, particularly winter chickpeas.

Crop response to inoculation is usually measured through grain yield and nitrogen content (grain + straw). As pointed out by Beck (1989), inoculation response is very difficult to assess when evaluating the effects of different strains on yield on a range of cultivars. Inoculum development requires rigorous quality control and specific infrastructure for production and distribution which are lacking in most countries of the region. In addition, national programs have little experience on the subject. <u>This is another subject area where ICARDA has a considerable comparative advantage over national programs</u>.

In collaboration with national scientists, ICARDA is initiating a number of surveys in the region aimed at identifying local rhizobia strains. Once identified, these strains are developed so that inoculation, with local appropriate strains, is possible whenever necessary.

The EPR panel has indicated that "there is by no means universal agreement on how effective legumes are in contributing nitrogen levels to the soil of dry areas". Except under low rhizobium efficiency, e.g. Sitona damage, legume contribution to the soil nitrogen budget seems to be well documented. Rather, the issue relates to the residual nitrogen after removal of the legume crop. A proportion of the nitrogen fixed is reexported from the soil via the harvested grain and straw. It may well happen that the amount of nitrogen removed by the legume may be higher than the amount it fixed, resulting in a negative nitrogen balance. According to Beck (1989), between 80 and 120 kg/ha of nitrogen are removed from the soil as seed by winter-sown chickpeas. If straw is also removed then a negative balance will result. The negative nitrogen balance worsens in the case of spring sown chickpeas (Fig. 2).

Fig. 2. Crop nitrogen yield, distribution and source in winter and spring sown chickpea cultivar ILC 482, for 1986-87 and 1987-88 seasons. Proportions of nitrogen fixed during 1987-88 season are extrapolated from previous results. Tel Hadya, Syria.



Source: Beck, 1989.

Studies conducted in Syria (Keatinge, et al., 1983) suggest that rainfed food legumes, under relatively adequate environmental conditions, derive most of their nitrogen requirements through biological nitrogen fixation. Similar studies in Cyprus (Papastylianou, 1988) also reached the same conclusion. Karaca, et al. (opcit) have found that the amount of nitrogen provided by legumes was at least equal to the amount accumulated by fallow at seeding time of wheat. It was also indicated that higher cereal yields were obtained after food legumes compared with other crops in the rotation (Papastylianou, 1988; Welty, et al., 1988), and compared with fallow (Welty, et al., op cit.; Saxena, 1986). Experimental evidence suggests that, under actual agricultural practices of the region, nitrogen uptake by legumes is lower than the amount added by the legume crop through biological nitrogen fixation when only the grain is removed from the field, thus resulting in a positive nitrogen balance*. When

* When the legume crop is cut green, grazed, or harvested as hay early in the season, the amount of nitrogen added to the soil through biological nitrogen fixation is considerably greater.

the straw is also removed, negative nitrogen balances are usually reported.

On the other hand, there is little experimental evidence of a significantly positive nitrogen balance of fallow at wheat seeding time. If this is the case then substituting legumes for fallow will not negatively affect the soil nitrogen balance, to the contrary. Additionally, fallow is not cost free. It should be cultivated during the cropping season in order to achieve its presumed goals, mainly weed control and water storage.

When a legume crop is harvested for both grain and straw, it may be necessary to add more nitrogen to the subsequent wheat crop in the rotation, compared with a fallow-wheat sequence. Assuming this is true, the extra income the farmer gets from the legume crop (grain + straw) more than offsets the extra fertilizer cost, thus leading to a much larger profit with the legume-wheat rotation, compared with fallow-wheat, over the two year period.

The most common cropping systems in the region are cereal-cereal or fallow-cereal. The negative effects of continuous cereal cropping on the sustainability of the production system are well known and do not seem to be disputed, by scientists, although continuous cereal cropping is still widely practised by farmers. If legumes (food and/or forage) are used in place of fallow, their effects on the farming system should be weighted against that of fallow. Experimental evidence suggests that fallow does not outyield legumes in terms of soil water and soil nitrogen balances available for the subsequent wheat crop at <u>seeding time</u>. On the other hand, net returns from the legume-wheat sequence are normally much higher than that from the fallow-wheat sequence (over the two-year period). Farmers' behavior vis a vis the rotation to adopt, is likely influenced primarily by the overall profitability of the cropping sequence and how different options fit their available resources, especially labour supply.

In the region, the sustainability of the production system is seriously jeopardized by continuous cereal cropping. In addition, a limited resource base coupled with growing food deficits and severe social pressures (high population growth rates), call for the gradual reduction of fallow. In either scenario, legumes (food and forage) constitute a desirable alternative for the rainfed cropping system.

5. Main Problems Affecting Food Legume Production

5.1. Economic and Social Problems

Based on the analysis in section two of this report we do not feel that in general there is a demand constraint obstructing the expansion of food legume production in the WANA region: the growth of actual and projected *per capita* demand at the level of individual countries in WANA; the projections of world market demand, and the rising imports of food legumes into the region all point in the opposite direction.

This does not mean that there is no demand constraint affecting production of specific food legumes within individual countries. We have noted for example, that lentils are not preferred over chickpeas or faba beans in Tunisia even though they could be produced there; and that Faba beans are the preferred food legume in North Africa, whereas chickpeas and lentils are more widely consumed in West Asia. Since traditional diets tend to be conditioned to a considerable extent by ecological conditions, and most of the food legumes have been around in the WANA region for millenia these apparent preferences may have their origins in the prevailing national ecologies.

Economic factors are increasingly being superimposed on biological ones, especially as labour costs are rising and more people are moving out of agriculture into cities or to part time off-farm work in rural areas. Lower international prices may persuade governments that it is cheaper to import than to subsidize local prices at high levels: this may lie behind the decline in chickpea production in Jordan, where *per capita* consumption of this crop is quite high. If lentil costs of production can not be brought down it is possible that imports will start to rise as rapidly in other countries as they have in Algeria, in order to satisfy demand. *The constraint is on the supply rather than* the demand side.

This seems largely to be due to differences between the profitability of cereals and food legumes, due to the lower yields and higher production costs of the latter, although in some countries there also appear to be perceptions among farmers that the legumes are a more risky enterprise. Our review of the comparative variability of cereal, lentil, and chickpea yields in seven countries of the WANA region does not indicate that there are major differences among these crops in coefficients of variability due to weather; but the rather high risk of Ascochyta losses in some countries, and the instability of legume prices compared to those of wheat, due mainly, to government price support to that crop, may contribute to producers perceptions of higher risk from growing legumes. Wheat invariably receives preference over other food crops in terms of price policy and input subsidies, until recently prices of barley and legumes in WANA countries were not secured by floor prices or other devices. This has changed in some countries (Turkey, Syria and Algeria for example), but in most others they have no stability or are supported at very low levels.

Lentil yields in the region are about 60% of the average yields of wheat, and 66% of barley yields, while chickpea yields average 70% of wheat and 75% of barley yields. Faba bean yields generally exceed those of wheat in terms of national averages, but this may be misleading since they may often be competing with irrigated wheat where yields are more than double those of wheat in rainfed areas.

On the other hand there are striking differences between the world prices of cool-season legumes and cool season cereals (wheat and barley). At 1988 world prices most of the food legumes have an international price advantage 2 1/2 to 3 times that of wheat and considerably more over barley prices although this is not always reflected in domestic prices.

These price comparisons suggest that those producing countries in WANA which are deficit in food legumes should be giving higher priority to increasing their domestic supply in order to reduce imports, even if this means increased imports of wheat or barley. Countries of the region which have a comparative advantage for legume production in ecological terms (as in Turkey) and can produce at costs comparable with import prices might attempt to develop exports of legumes for food or feed. This might be a better use of domestic resources than attempting to devote even more land to production of rainfed cereals, which can be imported at a third of the price of food legumes and do not produce an equivalent <u>gross</u> value per hectare at current average yields.

Unfortunately the <u>net</u> returns from food legumes are often lower than those of cereals, not so much due to their lower yields as to their higher costs of production. This is due largely to their high labour requirements, which are being aggravated by rising prices of labour in the region. Modern cereal production involves little manual labour; but for food legumes, and lentils in particular because of their short stature and more prostrate growth habit, competition from weeds is greater, and hand weeding and manual harvesting are often difficult to avoid.

Consequently data from farm surveys suggests that <u>net</u> profit margins from lentils, even at current higher prices and allowing for the higher value of the straw, are often inferior to those of wheat (Nordblom 1985 opcit). Those from chickpeas are rather higher but are often only marginally better than wheat. Thus it is essential to raise yields of both crops; and, especially in the case of lentils, to reduce actual costs of production by mechanization of harvest operations even if this does not actually increase yields. If both objectives can be achieved, so much the better

<u>We suspect that ICARDA is not paying enough attention to comparative analysis of national price policies, actual prices received by farmers, costs of production for competing commodities, and the effects of price incentives on farmers' choice of enterprises in the WANA region. This may be due to the current shortage of economic</u>

<u>expertise on its staff</u>. While it is true that prices tend to be ephemeral, and that the choice of enterprises in rainfed agriculture under winter rainfall sub-tropical conditions is lower than in irrigated land; a better understanding of price relations, components of costs, and the magnitudes of the price differences which may have to be overcome to achieve price parity can provide useful guidelines as to research priorities and to the short and longer run lines of research which may prove most effective in producing results acceptable to farmers. For example, in the case of lentils, reducing production costs by mechanization and finding a good selective herbicide may be the key short run objectives to expansion of the area under crop; while the longer-term breeding objectives leading to a more productive plant type are being pursued. With chickpeas, breeding for Ascochyta resistance and winter hardiness might take precedence over reducing short run production costs.

It is also most important, in our view, for ICARDA to be able to play a more positive role in influencing policy decisions by governments, especially where the means proposed to implement policies seem likely to be ineffective. There is not much point, for example, in providing price 'guarantees' for a crop which are too low (compared to yields and costs of alternative crops.) to provide any incentive to growers to change their enterprise-mix, or which can not be backed up by an efficient and geographically well distributed purchasing organization. Decisions as to domestic price policies, especially where imports or exports may be involved, need to take account of border prices, international markets, and comparative advantage in the light of domestic resource costs.

Food legumes may in fact be good prospects in this light, and both the review of world market demand in section 2 above and individual World Bank studies of comparative advantage in WANA countries e.g. Turkey, Tunisia, and Syria suggest that this may be the case. However, their prospects are bleak if domestic prices for wheat are stacked against them because of self-sufficiency syndromes on the part of national policy makers. ICARDA should not shirk from addressing such issues, since if it fails to do so important elements of its research may be off target, or not acceptable to producers for economic reasons.

5.2. Technical Problems

5.2.1. Physiological

Present food legume yield data of most countries in the region unequivocally illustrate the low competitiveness of these crops in WANA farming systems. The inherently low yield potential of the widely grown landraces is usually identified as the major cause of the low crop output.

The frequency and distribution of annual rainfall are paramount in rainfed agriculture as crop production depends on soil stored water. One of the major characteristic of the WANA region is the considerable temporal and spatial variability of rainfall and the high amplitude between seasonal and day-night temperatures. Food legumes are particularly sensitive to variations in day length (photoperiod), diurnal and nocturnal temperatures. Early maturing genotypes are usually less affected by the environment because of the higher probability of drought avoidance late in the season. Summerfield (1981) has indicated that young lentil plants are able to support a sever frost, but may be destroyed if the frost has a long duration and high frequency or when desiccating winds prevail. Furthermore, the plant water uptake seems to be reduced by low night temperatures, implying that cold tolerant genotypes may also exhibit tolerance to "physiological" drought. Stress from salinity, drought and heat may be the cause of considerable reduction in the productivity of legumes, particularly lentils.

The low yield levels recorded in the region are probably the result of the interaction of inherent morphological and physiological "Weaknesses" e.g. plant structure, susceptibility to lodging, shattering, etc., with unfavorable environment conditions. In legume production, genotype, environment, and rhizobium effects are confounded. In order to distinguish between these factors and quantify their impact on yield formation, it is necessary to design and implement experiments whereby the researcher can assess, with relatively good accuracy, which of the factors limit legume production the most (Mytton, 1986). It is therefore, essential to seek to understand the various means through which legume genotypes can adapt to the environment where they are grown.

Legume crops are often grown under conditions of agronomic neglect. In general, the priority is given to cereal at the farm level, e.g. lentils are not sown until cereal planting is completed. This practice leads to suboptimal dates of sowing which may affect plant growth as a result of poor stand establishment. The effect of date of sowing and plant density on yield is well documented. Delayed sowing may lead to considerable yield losses as illustrated in Table 16 and Figure .

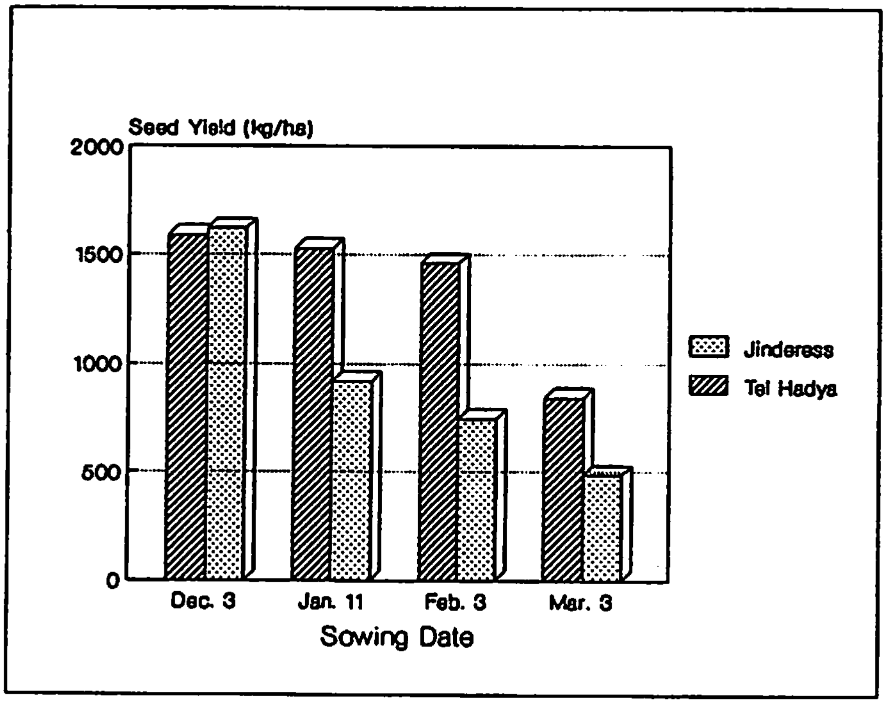
Table 17. Effect of date and rate of sowing on the seed and straw yield of lentils (cultivar ILL 4400) averaged over 3 row spacings, at Tel Hadya, Syria. 1977-78.

Date of sowing	Sowing rate (kg/ha) 80	120	160	200	LSD 5%
	Seed Yield (kg/ha)				
December 4	865	948	1008	1029	
December 28	564	647	605	657	
January 31	94	98	113	98	71.7
	Straw yield (kg/ha)				
December 4	1434	1580	1763	1766	
December 28	1194	1161	1194	1283	
January 31	458	526	569	627	133.0

Source: Saxena, 1981.

Although site specific, these experimental results do give an approximation of the proportion of yield lost as a result of late sowing, which seems to be a common practice in the region. However, early sowing aggravates weed competition for water, nutrients and light, particularly for lentils because of their low growth rate in the early vegetative phase. Early sowing also increases the probability of frost damage. The development of new lentil cultivars with improved standing ability (for better competition with weeds) and resistance to pod dehiscence and shattering (to improve effectiveness of mechanical harvesting), and cold and drought tolerance, will considerably enhance the crop productivity. For chickpea, early (winter) sowing is subordinate to the availability and adoption, by farmers, of new genotypes resistant to diseases, especially ascochyta and wilt, and tolerant to cold. The possibility of occurrence of ascochyta increases with the earliness of sowing, due to favorable moisture and temperature conditions.

Figure 3. Effect of sowing date on seed yield (kg/ha) of chickpea (average of 4 cultivars) sown in Tel Hadya and Jinderess, Syria, 1986-87.



Source: Adapted from Saxena, et al 1987.

Silim, et al. (1987) have found significant genotype variations when investigating lentil response to total moisture supply under different moisture regimes at Tel Hadya and Breda, Syria (Table 18). Based on their findings, they suggested three broad groups of genotypes: (1) genotypes with high seed yield under limited moisture supply and responsive to increasing moisture supply, e.g. ILL 16; (2) genotypes with low seed yield under limited moisture supply but very responsive to increasing moisture supply e.g. ILL 101, and (3) genotypes with moderate yield under limited moisture supply and moderately responsive to increasing moisture supply, e.g. ILL 4401.

The amount of fertilizers applied to legume crops is often limited in the region. It is expected that mineral nutrient requirements of new genotypes, adapted to early sowing, would be much higher compared with local cultivars, due to yield differentials (Pala and Mazid, 1987). Therefore, if farmers' behaviour is not adjusted to fit the new practice, i.e. early sowing, as it develops, the potential yield gain from early sowing may be jeopardized by the low level of mineral nutrients, a common characteristic of legume areas in the region. In soils exhibiting low fertility levels, an adequate supply of the essential nutrients is a prerequisite for higher and stable legume yields. This is particularly crucial during the stand establishment phase of the crop.

A considerable number of new cultivars of lentils, chickpeas and faba beans (see Table 27) have been released, or are being considered for release by national programs, in collaboration with ICARDA. This new material has been selected according to the genetic traits required in the specific production areas, e.g. seed size, plant habit, disease resistance, cold and drought tolerance etc.,. As indicated by Summerfield (1981), to increase legume yield from rainfed areas, involves objectives which include responsiveness of the new genotypes developed, to improved agronomic practices, adaptation to the edaphic and aerial environment and to water availability.

Throughout the region, there exist sizable gaps between the research station and farmers' yield*. In order to narrow the yield gap, it is necessary to evaluate the new technology under farmers' conditions before making any unwarranted recommendations. It is also

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* This holds for cereals too.

Table 18. Effect of total seasonal moisture supply on seed and biological yields (kg/ha) of diverse lentil genotypes sown in Breda and Tel Hadya, 1986/87.

Genotype	Origin	Seed yield in kg/ha					Biological yield in kg/ha				
		Breda	Tel Hadya				Breda	Tel Hadya			
		Rainfed (244.6mm)	Rain cut (272.6mm)	Rainfed (340.4mm)	Irrigated (525.1mm)	Mean	Rainfed (244.6mm)	Rain cut (272.6mm)	Rainfed (340.1mm)	Irrigated (525.1mm)	Mean
ILL 8	Jordan	127	1644	2189	3166	2333	1303	5106	5406	8117	6210
ILL 9	Jordan	172	1599	1766	3354	2240	1596	5101	5104	8564	6256
ILL 16	Jordan	324	1783	1919	3304	2335	1509	4654	5177	8521	6117
ILL 101	Syria	66	953	1379	3269	1867	1088	4077	4824	8332	5744
ILL 223	Iran	260	1689	1989	3263	2313	1395	4791	5289	8116	6065
ILL 470	Syria	225	928	1328	2355	1537	1089	3457	4424	7163	5014
ILL 793	Egypt	57	805	1156	2458	1473	583	3830	4477	8055	5454
ILL 1861	Sudan	251	1249	1595	2948	1931	1319	4417	4868	8444	5909
ILL 4349	USSR	28	676	1000	2154	1277	869	3912	4322	7601	5278
ILL 4354	Jordan	255	1881	1962	3289	2377	1514	5157	5177	8117	6150
ILL 4400	Syria	75	1223	1254	2925	1801	1324	4486	4626	7947	5686
ILL 4401	Syria	220	1368	1433	2346	1716	1233	4258	4669	7262	5396
ILWL 7			179	182	261	207		879	834	1063	925
Mean		172	1229	1473	2699		1235	4163	4553	7485	
			(M)	(G)	MxG		(M)	(G)	MxG		
L.S.D.(.05)		48.7	129.1	243.8	425.1	244.7	428.5	565.8	1032		
C.V. (%)		19.8	14.9	16.7		13.8	16.5	13.0			

(M) - moisture, (G) - genotype

Source: Silim et. al., 1987

essential that, at national levels, no effort should be spared to make the new cultivars available to farmers in order to gradually replace the current cultivars used. The challenge facing research is to increase and stabilize yields of legumes so that they will become more profitable. Such a challenge can be met if genotypes that exploit fully the potential of the environment are developed. To quote Buddenhagen (1988), "Food legumes have been called the step-child of the green revolution because their breeding has not resulted in major yield gain".

5.2.2. Diseases

Food legumes suffer low productivity due to susceptibility to diseases. Because they depress yield, diseases adversely affect the profitability of food legumes. As such, they constitute a major limiting factor to area expansion and may lead to area reduction over time. Although difficult to estimate with accurancy, economic loss due to diseases is quite substantial in the region, especially when favorable environmental conditions for the development of the responsible pathogens prevail. Despite the fact that major food legume diseases have been reported as early as 1918*, they remain little understood, especially those caused by viruses and root pathogens (Buddenhagen, 1988). In the region, substantial crop damage is caused by a few major diseases.

Chickpeas

Ascochyta blight is undoubtedly the most important disease limiting chickpea production. It has been reported (Harrabi 1986) that this disease, under favorable conditions for its development and spread, may completely wipe out a chickpea crop. The success of winter chickpea technology may even be hindered by the disease. It is, therefore, crucial that winter planting chickpea varieties have ascochyta resistance (in addition to cold tolerance). Fusarium wilt, particularly in North Africa, and root rot also cause serious damage to

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* According to Harrabi (1986), ascochyta blight was first reported in 1918 by Butler in the North West Frontier Province of India (Now Pakistan).

chickpea. Genetic resistance of the new material developed is the only effective avenue for coping with these diseases. In order to minimize the risk of disease damage that may be associated with winter planted chickpea, ICARDA breeding program strategy is geared toward 3-way genetic resistance, i.e. combined resistance to ascochyta, fusarium wilt and cold.

Table 19. Occurrence of important food legume diseases and pests in the WANA region.

Disease	Occurrence endemic	Occurrence epiphytotic
Chickpea		
- Ascochyta blight		WANA
- Fusarium wilt	North Africa	
- Stunt	WANA	
- Cyst nematode	West Asia	
Faba bean		
- Ascochyta blight		WANA
- Chocolate spot		WANA
- Rust		WANA
- Stem nematode	WANA	
- Bean leaf roll virus	WANA	Syria (Coastal area)
- Bean yellow mosaic virus	WANA	Sudan
- Broad bean mottle virus	WANA	Sudan
Lentil		
- Fusarium wilt	West Asia	
- Rust	Morocco	

Table 20. Crop losses caused by important chickpea diseases in the WANA region.

Disease	Country	Estimated yield loss (%) or US$	Reference
Ascochyta blight	Morocco	US$ 10 Mil.	Kamal 1984
	Pakistan	46-48%	Malik, 1986
	Syria	30%	El-Mott, 1984
	Tunisia	40%	Mlaiki and Hamdi, 1984
Fusarium wilt	Pakistan	US$ 1 Mil. (yearly)	Sattat et al. 1953

Source: Adapted from Mamluk, et al. (1988).

Lentils

Vascular wilt, caused by Fusarium oxysporum is considered a the most important pathogen of lentils, particularly in the Mediterranean region. Botrytis, ascochyta blight and rust have also been reported as major pathogens causing yield instability in the Indian subcontinent (Malik et al, 1988).

Faba bean

It is largely admitted that botrytis, ascochyta blight and rust (Hanounik and Maliha, 1983) constitute the major diseases limiting faba bean production. Botrytis, ascochyta blight and rust crop damage has been evaluated to 67%, 62% and 40%, respectively (Hanounik, 1979, 1981; Williams, 1978).

Chemical control of food legume diseases is not a common practice in the region. Legume seed treatments usually reduce disease infections and spread. Fungicides such as Calixin M and Thiabendazole provide an effective control of seed borne inoculum of Ascochyta rabiei. Benlate T, on the other hand, gives good control of chickpea wilt through seed dressing. However, chemicals can only provide limited disease control. Their use may not be economically justified either. Genetic resistance represents the only viable and most effective alternative to legume disease control. Germplasm screening, effective selection and breeding for disease resistance is the approach pursued by ICARDA. Preventive measures, e.g. seed dressing, enhance the effectiveness of the legume cultivar to sustain disease infectious. Several breeding lines with resistance to the diseases prevailing in the region have been identified by ICARDA.

Table 21. Selected sources of resistance available for food legume diseases.

Disease	Resistant sources
Chickpea	
a. Ascochyta blight	ILC-72, 201, 202, 2506, 3274, 3279, 3956, 4421,
b. Fusarium wilt	ICC-3634, 4200, 4248, 5124, 6981, and ICC lines (over 100), ICCC 32, ICC-2,3,4 and 5.
c. Stunt	ICC-403, 491, 685, 2385, 2546, 3718, 6433, 6934, 10495, 10596.
Faba bean	
a. Ascochyta blight	BPL 2485 and Sel. 80 Lat.
b. Chocolate spot	ILB-938
	BPL-710, 261, 266, 678, 43, 470.

Source: Adapted from Mamluk, et al. (1988).

5.2.3. Insect pests

Over 50 species of insect pests attacking faba bean, chickpeas and lentils have been recorded in the WANA region. Only few pose a real economic threat, though (Cardona, 1983). Insect control (chemical and/or cultural) is not a widespread practice in the region. On the other hand, it seems that most chemical insect control studies undertaken in the region lack economic analysis. Therefore, it is quite difficult, in most cases to identify the economic threshold of insect control.

Faba beans

The most important insect pests on faba beans are aphids. Faba bean are also affected by the sitona weevil and leaf miner (Cardona, 1983). In order to better asssess the aphid problem in the West-Asian region, an aphid screening research network has been developed. A potential extension of the network to cover North Africa is also being considered. It is reported (ICARDA, 1988) that a great deal of progress was achieved in terms of a better understanding of the biology and control of leaf miner, through work in the Nile Valley Project in the Sudan.

Chickpeas

Leaf miner and Heliothis are the most serious field insects that attack chickpeas. It has been indicated that Heliothis damage is more important in winter planting. It is, therefore, expected to become even more severe as winter planted area of chickpea expands. It must be pointed out, however, that it is relatively difficult to estimate, with reasonable accurancy, what proportion of yield loss can be attributed to leaf miner and heliothis, respectively.

Lentils

The sitona weevil is undoubtedly the most serious insect pest in the region. How much nodulation activity is affected by sitona damage is not very well known and necessitates more investigation. So far, screening for host plant resistance has not been successful. Chemical control, through carbofuran treatment, is recommended. However, generally low (non-significant) correlation between nodule damage and yield casts doubt on the profitability of the treatment.

Storage pests

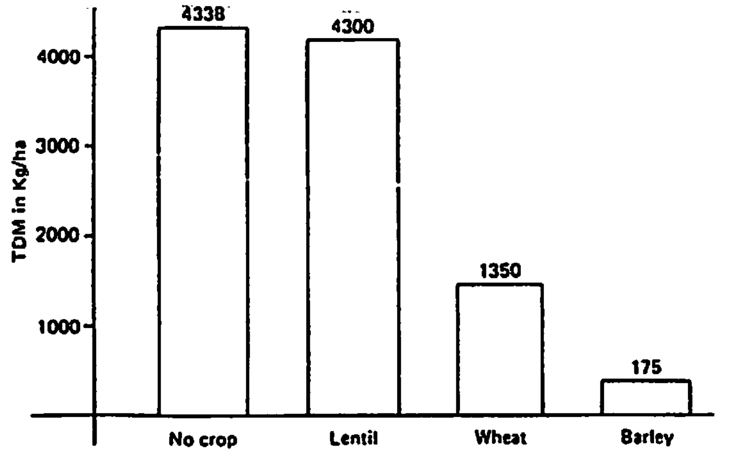
Throughout the region, bruchids are considered a very important storage pest. Bruchids cause considerable damage in food legumes. Studies have shown that Bruchus dentipes affects up to 90% of faba bean seeds in Syira. Information on bruchid importance in lentils is lacking. Therefore, a survey aimed to assess bruchid damage in lentil has been undertaken by ICARDA in collaboration with national programmes. An integrated control approach combining the use of bruchid free seeds, ploughing for timely chemical control, seed fumigation during storage, is strongly suggested in order to reduce production and quality losses.

5.2.4. Weeds

Weeds represent a major constraint to food legume production. Compared with other crops grown in the region, e.g. cereals, food legumes (except for faba beans) are more sensitive to weed competition because of their morphology.

Basler (1981) has indicated that lentil yield, contrary to other crops, can be severely depressed even when the crop is established under weed-free condition, i.e. lentil plant structure does not prevent late establishment of weeds.

Fig. 4. Total weed dry matter (TDM) produced in an entire cropping season under uncropped, lentil, wheat and barley situations.



Source: Basler, 1981.

The inherently low competitiveness of legumes, particularly lentils, coupled with the lack of effective herbicides, especially for post-emergence control, and poor crop management, constitute a serious threat and aggrevate yield instability, i.e. high production risk, in the region. Th effect of weeds is much higher in winter planting. Therefore, unless effective weed control methods are developed, weed competition may hinder the expansion of winter sown chickpea.

Research initiated by ICARDA has revealed the effectiveness of some herbicides, or combination of herbicides, e.g. Kerb + Igran, for chemical weed control. However, most of the chemicals are pre-emergence. In general, farmers do not initiate weed control operations until they see the weeds. This, perfectly rational behavior has limited the use of pre-emergence herbicides; as well as the low selectivity of common herbicides in lentils, for example. Weed control is another research area for which ICARDA does have a much better comparative advantage over national programmes. Obviously, the role of ICARDA should not be to develop chemicals, but rather to test them for their saftey vis-vis humans, livestock, and the plants, potential side effects and carryover, etc., before including them in international trials to be conducted by national programmes.

Orobanche

This parasitic weed may cause the total loss of a crop. Orobanche parasitazes faba beans, lentils, chickpeas and peas, although it is usually more severe on faba beans and to a lesser extent on lentils. An Orobanche plant infecting a legume plant drains all the nutrients so that the host plant usually dies before setting seeds. The infestation may be so severe, e.g. Morocco and Tunisia, that farmers are forced to quit growing legumes. Infested crops are destroyed and ploughed down, resulting in total loss to the farmer. According to Kukula, et al. (1983), although chickpea sown in the spring is resistant to Orobanche crenata, its resistance is much lower when it is planted in the winter. Attempts to control Orobanche chemically (glyphosate) have had little success, so far. In many cases infestation was not reduced and considerable damage was done to the treated plants. Orobanche control constitutes an important research subject at ICARDA. For the last three years a research program has been conducted in close collaboration with the University of Hohenheim (W. Germany). Control measures including soil solarization, different sowing dates, chemical treatment (with old, e.g. glyphosate, as well as new herbicides, e.g. imazaquin) and single plant selection of resistant cultivars, have been tested through this collaborative research effort. The results show that Orobanche was reduced by all the single treatments, although solarization was found to be the most effect in increasing faba bean yield. A combined treatment including solarization, delayed sowing and glyphosate treatment resulted in the highest faba bean yield and a 100% control of Orobanche.

It must be pointed out, however, that solarization is very costly to apply (about US$ 500/ha). An economic evaluation of the Orobanche control studies indicated that the combination of delayed sowing plus glyphosate was the most economical control measure.

5.2.5. Mechanization

Despite high levels of mechanization of cereal crops, food legume remains highly labor intensive in the WANA region. The low degree of mechanization of those crops has had two major results:

- High production costs due to higher labor requirements and rising wages.
- Decline of food legume area due to lower competitivenesses with other crops, especially cereals, and labor supply bottlenecks at critical peak seasons, e.g. harvest.

The mechanization of food legume production is a subject of considerable interest in the region. Drill-seeding is not wide-spread and chemical weeding is virtually absent*. The most commonly practiced seeding method includes broadcasting the seeds over ridges and then split the latter to cover the seeds, e.g. Syria. Row planting (wide spacing) allowing for interrow cultivation is also common. The major disadvantages of these methods are:

- Uneven sowing depth leading to heterogeneous emergence and stand establishment.
- Uneven soil levelling (ridges) which impedes the mechanization of harvest.
- Lower than optimum plant density (per unit area) with wide spacing, resulting in yield reduction.

The mechanization of food legume seeding does not necessarily require special equipment. Most cereal drills may be used, although some minor adjustments may be required. Soil levelling, with a bar behind the drill, and rolling after planting (before emergence) improves considerably the performance of mechanical harvesting.

An often mentioned, a major impediment to legume production improvement is hand harvesting. High labor requirements, high labor wages and acute labor supply bottlenecks at harvest time have rendered hand harvesting a very costly operation**.

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* It must be pointed out, however, that no effective post-emergence herbicide (broad leaves) seems to be available either.

** Because of labor supply bottlenecks, hand harvesting may induce yield losses due to pod dehiscence and drop when harvest is delayed.

The inherently low yield potential of legume landraces currently grown, coupled with high "hand harvest induced" costs of production have substantially reduced the economic competitiveness of legumes. This has led, in some countries of the region e.g. Algeria, to a sharp decline in the area devoted to legumes, particularly lentils. Policy makers, scientists and farmers unanimously consider hand harvesting as the major lentil production constaint*. Combines, mowers, cutter bars, etc., extensively used for cereals and hay, in the region, are rarely used for legumes. Yet, in many other countries. e.g. USA, Canada, Europe, South America, New Zealand and Australia, combine harvesters are extensively used for legume harvesting, either direct or two-step harvesting, (Khayrallah, 1981; Erskine, et. al, 1988). Mechanical harvesting does not seem to be a constraint to lentil production in these countries**. Why then is the use of such technology so limited in the region? Unacceptably high losses of seed and straw induced by mechanical harvesting are often reported as the most important factors limiting mechanical harvesting technology. It is worth noting, however, that these losses are not only related to the inadequacy of the equipment but also to crop management practices and plant growth habit***.

Poor seedbed preparation resulting in uneven soil surface, high weed infestation, coupled with ridge planting, e.g. Syria, does not facilitate mechanization. The quasi exclusive use of landrace cultivars characterized by a short stature, pronounced lodging habit and susceptibility to shattering due to pod dehiscence and drop (Erskine, 1985) constitute another major impediment.

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* Because of their plant structure, faba beans and to a lesser extent, chickpeas are much easier to mechanize. The mechanical harvesting constraint, therefore, applies mostly to lentils.

** It has been reported that this technology is also used on a large scale in Algeria, for example, (Haddad, et al. 1988; Benbelkacem, 1988).

*** As indicated by Muehlbauer (1985), "Lentil is nearly all harvested mechanically in North and South America; however, the cultivars are tall, and the soils are devoid of stones".

An extensive research effort, by ICARDA, has sought to remove these limitations. The research work concentrates on improving, through breeding, the plant architecture and the resistance to pod dehiscence. Various mechanical methods, e.g. combines, cutters, double knife cutter bars, pullers, etc., under different crop management scenarios, are compared with hand harvesting*. Invariably, the results of these studies highlight yield losses (seed and straw) which reduce substantially the harvested yield. Lentil straw is highly valued in the region, It is, therefore, expected that any harvesting method which negatively affects straw yield will have a low probability of adoption**. However, price data from the region indicate a substantial increase in legume output prices during the last five years. In Syria, for example, output prices have risen by up to 300% between 1985 and 1988. According to Salkini and Erskine (1987), lentil production has become a very attractive enterprise in Syria***.

Under current production conditions an average yield loss of 15% and 20-25% of seed and straw, respectively is caused by mechanical harvesting compared with hand harvesting****. The yield loss usually translates to an average 10-12% loss in net benefit, over pulling or cutting cost only, (Erskine, et al. 1987). Although other studies (Salkini, et al. 1988) show that net benefit from mechanical harvesting despite seed and straw loss, could be as high as 4% over hand harvesting, mainly because of exhorbitant labor harvest costs.

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* Local landrace and newly developed cultivars are sometimes inlcuded in the comparisons to account for cultivar effect.

** The loss may be an important factor only when all the straw is marketed, i.e. no animals on the farm, which is quite rare in the region. Otherwise, the straw left on the field, as well as the seed, is recuperated through grazing, not to mention its contribution to soil fertility and structure.

*** Between 1984 and 1987, lentil area has increased by nearly 50%, from 59,500 ha to 89,000 ha, respectively.

**** It is worth noting that yield losses of seed and straw are also present in the case of cereal mechanical harvesting. Yet, farmers use combine harvesters quite extensively.

Table 22. Partial budget of average date of lentil harvesting mechanization trials in Village Project, 1987-88, Syria.

	Hand	Machine	% Change
Grain yield (kg/ha)	1350	1185	-12
Straw yield (kg/ha)	1750	1585	-09
Grain revenue (SL/ha)	10330	9080	-12
Straw revenue (SL/ha)	1800	1630	-09
Gross revenue (SL/ha)	12130	10710	-12
Harvest costs (SL/ha)	2220	400	-82
Net benefit over harvest costs only (SL/ha)	9910	10310	+04

Source: Salkini et al., 1988.

Table 23 (P:99) shows that the new cultivar ILL 16 yielded significantly more than the local check Hurani 1. A significant genotype X harvest method interaction showed that seed yield of ILL 16 was not reduced by mechanical harvesting, whereas the yields of both the local cultivar and ILL 223 were affected (Erskine et al, 1987. op cit.). Machine harvesting of ILL 16 does not cause any significant loss in net benefits. It allows, however, the avoidance of labor bottlenecks. If 1988 prices and harvest costs are used, then machine harvesting of ILL 16 will result in a net benefit of 1031 SL/ha, compared with hand harvesting, mainly because of harvest costs increase: 58% and 122% increase for machine and hand, respectively.

Table 23. Partial budget of three genotypes and their average performance in the village trials in 1986/87 season.

Details	ILL 16		ILL 223		Hurani 1		Mean	
	Hand	Machine	Hand	Machine	Hand	Machine	Hand	Machine
Grain yield (kg/ha)	1919	1922	1822	1321	1698	1526	1813	1589
Straw yield (kg/ha)	2328	1864	2217	1326	2554	1974	2366	1721
Grain revenue (SL/ha)	11508	11532	10938	7926	10188	9156	10878	9534
Straw revenue (SL/ha)	4074	3262	3879	2320	4470	3455	4140	3012
Total revenue (SL/ha)	15582	14797	14817	10246	14658	12611	15018	12546
Pulling or cutting cost (SL/ha)	1000	252 [a] 132 [b]	1000	252 [a] 132 [b]	1000	252 [a] 132 [b]	1000	252 [a] 132 [b]
Net benefit over pulling or cutting cost only (SL/ha)	14582	14542 [a] 14662 [b]	13817	9994 [a] 10114 [b]	13658	12359 [a] 12479 [b]	14018	12294 [a] 12414 [b]

a) Upper limit of mechanical cutting cost
b) Lower limit of mechanical cutting cost
Lentil prices, Grain = 6.00 SL/kg
Straw = 1.75 SL/kg

Source: Erskine, et al. 1987.

So far, economic analysis of hand vs mechanical harvesting has been confined to simple partial budgeting. Beyond the profit, consideration, labor availability may very well affect farmers' decisions regarding the adoption of a labor saving technology. Manual harvesting increases seasonal demand for labor, particularly at harvest. Hand harvesting is therefore unlikely to be attractive for farmers with limited family labor or with less access to labor markets*, not to mention the scarcity of peak season labor which increases wage rates. One of the major purposes of mechanical harvesting is to alleviate labor bottlenecks and thus reduce production costs. Therefore, the tendency of mechanization studies to compare harvest methods in dichotomous terms, i.e. higher loss/lower loss, may be inappropriate because farmers' decisions are made over the whole farming system. Legumes are not the only crops grown on the farm. Simultaneous decisions accounting for ontime availability of labor, opportunity costs, risk, etc., are likely involved. As indicated by Nordblom et al. (1983), farmers may adopt a new technology which results in lower crop yields, but allows a significant saving in labor or other costs.

It is reasonable to assume that the more advanced farmers will have a higher opportunity cost for their labor resources. They are also likely to be more efficient in the acquisition of technical knowledge. It is therefore, assumed that this category of farmers will likely gain (in terms of total, as opposed to per unit area, net revenues) by adopting mechanical harvesting technology.

Intermediate farmers may reduce labor costs by adopting a two-step harvesting method whereby the crop is cut, swathed, and then threshed either with a combine or a stationary thresher. Depending on the level of management, combine harvesting may also be adopted.

Farmers in marginal areas (hilly and stony fields) with minimum management and low yields, have fewer options. Hand harvesting or, to

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* In the Mekness area, Morocco, farmers told us that they prefer to harvest chickpeas manually because of large supply of family labor (children on school holidays) with very low opportunity costs.

a lesser extent, mechanical pulling* and animal or mechanical threshing seem to be the only practical options.

As pointed out by Erskine, et al. (1988), the type of machinery recommended for mechanical harvesting of lentils relates to different target farmers groups, depending on the area planted, the local importance (value) of straw, the capability to prepare a flat seedbed, and the availability of labor, seed drills, and so on.

The performance of mechanical harvesting is affected by seedbed preparation, stoniness and topography of the fields, methods of seeding and plant habit. Farmers are rational entrepreneurs. If they are convinced (through on-farm trials and extension programs) of the benefits they can derive from mechanical harvesting of legumes, they would likely be willing to make an effort to improve the quality of land and seedbed preparation, use better and more adapted cultivars, etc., provided they are given the means to do so*.

The challenge facing legume research is to develop new high yielding cultivars with a plant structure which improves the performance of mechanical harvesting. Two plant traits should be jointly targetted by legume breeding programms: plant height and resistance to pod dehiscence. Success in this endeavor will be a major breakthrough in legume research that will benefit the countries of the region and beyond.

5.3. Institutional constraints affecting food and forage legume production in WANA

The ultimate value of an International Centre's research, however promising, depends on its adaption by its clients and beneficiaries

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* Because lentil area per farmer is relatively small in such environments, the purchase of a relatively expensive puller by individual farmers is not economically justified. This alterantive is plausible if there is a demand for custom work or if the puller is owned and used in a cooperative scheme. Mechanical harvesting technology, in general, is not neutral to scale. The "puller" alternative is even less so because of the very narrow range of crops for which it can be used.

(policy-makers, producers, and consumers) in the countries which that centre serves. International agricultural research is only a first stage in this process, many of the factors which determine successful adoption of new varieties, cultural practices, and farming systems, as well as consumer acceptance of the products of those systems, are beyond the influence of International Centres. They are largely the prerogatives of national governments, their policies, and the effectiveness of the institutions which they create to advance agricultural progress, and to meet the demands of domestic consumers and international markets.

Thus any serious weakness in key national institutions serving agriculture may limit the success of an International Centre's work. Those Centres may help governments to improve institutional effectiveness and accelerate the adoption of improved agricultural technology through policy research, material and other assistance to national institutions, and through training; but their ability to surmount serious institutional bettlenecks is limited. This section will review some of those constraints affecting ICARDA's work in the WANA region.

5.3.1. <u>Problems of national agricultural research programmes</u>

<u>Inadequate levels of funding</u>

In general agricultural research programmes in West Asia and North Africa are among the worst funded of those in any developing region, despite this region's relatively high national per capita incomes. Table shows that the average for the region as a whole, and for its three sub regions bareley exceeded 0.5 per cent of agricultural GDP , whereas FAO has suggested a target of at least 1 per cent for an adequately funded national agricultural research system (or about 10% of national agricultural investment), and the World Bank has stated that a figure of 2 per cent should be the target for 1990 in all but the poorest countries. Although the averages for the three sub-regional groupings in WANA have risen somewhat by the mid-1980's compared to 1975 and 1980 only two countries out of the fourteen for which financial data is available were spending more than 1 per cent of their agricultural GDP on research according to the most recent available data. These were Cyprus and Turkey. Only one country, Turkey, was allocating more than 10 per cent of its national agricultural budget to research. In eight out of sixteen countries it did not reach 2.0 per cent (Table 24).

This parsimony on the part of national policy-makers is reflected in some of the lowest levels of expenditure per scientist of any country - much lower, for example, than in Sub-Saharan Africa with the highest proportion of low-income countries. Thus it is not surprising that many national research scientists in WANA are at a financial disadvantage, compared both to their counterparts at universities and in the private sector, leading to high rates of turnover. In addition they tend to be starved of operating funds, short of research assistants and technicians (generally far below the desirable ratio of at least two trained technicians (diplomats) per scientist, and inadequately provided with vehicles and other essential field equipment.

Shortage of highly qualified staff

The quality of national research staff in the region in terms of experience and levels of training also leaves much to be desired. Except in North Africa where the average is higher because of the large scientific establishment in Egypt, and the high proportion of PhD level staff in Tunisia; the proportion of PhD staff in most national systems is very low: in thirteen out of seventeen countries it is below 15 per cent (Table 25). Even in large countries such as Morocco, Pakistan, Syria and Turkey it is under 10 per cent. Conversely staff trained only to B.Sc level exceed 50 per cent of the staff in twelve out of fifteen countries for which we have data. Numbers of expatriate researchers in national systems are low compared to Africa and Asia.

Organizational deficiencies

Not only are most national systems in the region inadequately financed and weakly staffed, they are often poorly organized as well. Reviews of several countries agricultural research establishments (for

Table 24. AGRICULTURAL RESEARCH EXPENDITURES (000 $ U.S.) West Asia and North Africa.

COUNTRY	YEAR	LATEST YR (1980 $)	1980 (1980 $)	1975 (1980 $)	AS % AG. GDP LATEST YR	AS % AG. GDP 1980	AS % AG. GDP 1975	AS % TOTAL AG. INVESTMENTS LATEST YR	$ PER CAPITA ($000, US 1980) LATEST YR	$ PER CAPITA ($000, US 1980) 1980	$ PER HA. ARABLE LAND ($000 US, 1980) LATEST YR	$ PER HA. ARABLE LAND ($000 US, 1980) 1980
NORTH AFRICA												
ALGERIA	1986	16,120	na	na	0.36%	na	na	0.97%	0.72	na	2.15	na
EGYPT	1983	32,793	30,214	21,248	0.70%	0.67%	0.54%	6.27%	0.73	0.73	13.27	12.36
LIBYA	1986	2,988	2,793	1,702	0.41%	0.50%	0.46%	0.30%	0.86	0.94	1.41	1.34
MOROCCO	1983	15,367	15,562	13,595	0.53%	0.48%	0.53%	3.89%	0.80	0.81	1.86	1.94
TUNISIA	1985	11,469	6,770	4,355	0.72%	0.55%	0.38%	3.55%	1.79	1.06	2.46	1.44
Sub total		78,737	55,339	40,900	0.55%	0.43%	0.38%	2.01%	0.81	0.62	3.15	2.24
WEST ASIA												
CYPRUS	1985	2,925	2,410	1,035	1.32%	1.17%	0.59%	4.77%	4.37	3.83	6.77	5.58
IRAN	1980	45,163	45,163	34,386	0.30%	0.30%	0.25%	1.18%	1.17	1.17	3.29	3.29
IRAQ	1983	18,623	4,030	1,993	na	0.15%	0.13%	1.51%	1.26	0.30	3.42	0.74
JORDAN	1980	850	850	750	0.36%	0.36%	0.45%	0.74%	0.29	0.29	2.14	2.14
LEBANON	1984	na	na	na	na	na	na	na	na	na	na	na
PAKISTAN	1986	17,903	31,757	30,620	0.23%	0.50%	0.59%	4.14%	0.17	0.37	0.88	1.56
SYRIA	1984	15,606	5,290	2,492	0.61%	0.20%	0.14%	3.35%	1.49	0.60	2.76	0.93
TURKEY	1984	112,965	30,000	22,900	1.22%	0.25%	0.21%	16.65%	2.49	0.66	4.17	1.05
Subtotal		214,035	119,500	94,176	0.55%	0.30%	0.28%	3.14%	0.98	0.60	2.92	1.60
ARABIAN PENINSULA												
BAHRAIN		na	na	na	na	na		na	na	na	na	na
KUWAIT	1983	na	na	na	na	na	na	na	na	na	na	na
OMAN	1983	na	na	na	na	na	na	na	na	na	na	na
QATAR	1983	2,010	na	na	na	na	na	na	7.28	na	670.00	na
SAUDI ARABIA	1983	10,000	na	na	0.58%	na	na	2.21%	0.94	na	8.82	na
UNITED ARAB EMIRATES	1983	1,239	na	na	0.37%	na	na	4.14%	1.03	na	82.60	na
YEMEN AR	1982	1,782	2,087	na	0.23%	0.28%	na	1.03%	0.28	0.35	1.32	1.54
YEMEN PDR	1985	531	na	na	na	na	na	1.23%	0.26	na	3.18	na
Sub Total		15,562	2,087	na	0.50%	0.08%	na	1.85%	0.66	0.10	5.73	0.78
Total		308,334	176,926	135,076	0.55%	0.32%	0.29%		0.91	0.57	3.05	1.73

Table 25. Scientific staff in National Agricultural Research Systems - West Asia and North Africa.

COUNTRY	YEAR	TOTAL SCIENTISTS LATEST YR	TOTAL SCIENTISTS 1980	TOTAL SCIENTISTS 1975	EXP. PER SCIENTIST ($000 U.S. 1980) LATEST YR	EXP. PER SCIENTIST ($000 U.S. 1980) 1980	NOs. SCIENTISTS/ MILL. $ AG. GDP LATEST YR	NOs. SCIENTISTS/ MILL. $ AG. GDP 1980	NOs. SCIENTISTS/ MILL. TOTAL POPULATION LATEST YR	NOs. SCIENTISTS/ MILL. TOTAL POPULATION 1980	NOs. SCIENTISTS 000 HA. ARABLE LAND LATEST YR	NOs. SCIENTISTS 000 HA. ARABLE LAND 1980	NOs. TECHNICIANS LATEST YR	NOs. TECHNICIANS/ SCIENTISTS LATEST YR
NORTH AFRICA														
ALGERIA	1986	267	na	na	60.37	na	0.06	na	11.91	na	0.04	na	na	na
EGYPT	1983	3,553	2,724	1,967	9.23	11.09	0.76	0.61	79.41	65.61	1.44	1.11	2,195	0.62
LIBYA	1982	82	123	75	36.44	22.71	0.11	0.22	23.62	41.37	0.04	0.06	na	na
MOROCCO	1988	507	200	103	30.31	77.81	0.18	0.06	26.23	10.35	0.06	0.02	462	0.91
TUNISIA	1985	237	285	99	48.39	23.75	0.15	0.23	37.08	44.59	0.05	0.06	322	1.36
Sub total		4,646	3,332	2,244	16.95	16.61	0.32	0.26	52.27	37.49	0.19	0.13	2,979	0.64
WEST ASIA														
CYPRUS	1985	97	55	57	30.15	43.82	0.44	0.27	144.99	97.44	na	0.13	213	2.20
IRAN	1986	626	580	550	71.92	77.87	0.04	0.04	16.25	15.01	0.05	0.04	347 (76)	0.55
IRAQ	1983	548	320	75	33.98	12.59	na	0.12	36.97	24.08	0.10	0.06	168	0.31
JORDAN	1986	115	99	35	7.39	8.59	0.49	0.42	39.34	33.87	0.29	0.25	38 (76)	0.33
LEBANON	1984	28	na	na	na	na	na	na	10.59	na	0.09	0.00	na	na
PAKISTAN	1986	2,500	2,634	2,645	7.16	11.21	0.32	0.45	24.30	32.90	0.12	0.14	na	na
SYRIA	1986	582	172	81	26.91	30.76	0.23	0.07	55.40	19.55	0.10	0.03	111	0.19
TURKEY	1985	1,630	943	540	69.30	31.81	0.18	0.08	35.91	20.84	0.06	0.03	580 (76)	0.36
Subtotal		6,128	5,003	3,983	34.93	23.89	0.16	0.13	28.05	25.22	0.08	0.07	1,457	0.24
ARABIAN PENINSULA														
BAHRAIN		13	na	na	na	na	na	na	na	na	na	na	na	na
KUWAIT	1982	2	na	na	na	na	0.07	0.00	4.87	0.00	4.00	0.00	na	na
OMAN	1983	42	13	na	na	na	0.33	0.13	36.78	13.21	0.98	0.32	na	na
QATAR	1983	7	na	na	267.14	na	na	na	25.36	na	2.33	na	na	na
SAUDI ARABIA	1983	171	na	na	58.48	na	0.10	na	16.04	na	0.15	na	na	na
UNITED ARAB EMIRATES	1983	12	na	na	103.25	na	0.04	na	9.96	na	0.80	na	na	na
YEMEN AR	1985	123	39	na	14.49	53.51	0.16	0.05	18.98	6.52	0.09	0.03	42	0.34
YEMEN PDR	1986	141	na	na	5.26	na	na	na	48.65	na	0.60	na	21	0.21
Sub Total		464	52	na	33.54	40.13	0.15	0.02	19.77	2.46	0.17	0.02	63	0.14
Total		11,238	8,387	6,227	27.44	21.10	0.20	0.15	36.45	27.20	0.11	0.08	4,499	0.40

Table 26. Distribution of Scientists by Commodity, Latest Year*

Country	All Cereals	Wheat/ Barley	Rice	Maize	Sorghum/ Millet	All Roots	Potato	All Pulses	Olives	Soya/ Oil seed	Sugar	Fruit	Vegetable	Tobacco	Cotton/ Fibers	Other Crops**	Total Crops
North Africa																	
Algeria	13	13				3	3	2		1							19
Egypt	98	61	21	12	4	7	4	64		27	36	153	153		145		683
Morocco	64	63		1		1	1	9		1	13	25	25		6	12	156
Tunisia	20	17	1	2		13	13	6	8	1	2	22	18	2	1	4	97
Sub total	195	154	22	15	4	24	21	81	8	29	51	200	196	2	152	16	954
% Total Commodity Scientists	12.0%	9.5%	1.4%	0.9%	0.2%	1.5%	1.3%	5.0%	0.5%	1.8%	3.1%	12.3%	12.1%	0.1%	9.4%	1.0%	58.8%
% Total Crop Scientists	20.4%	16.1%	2.3%	1.6%	0.4%	2.5%	2.2%	8.5%	0.8%	3.0%	5.3%	21.0%	20.5%	0.2%	15.9%	1.7%	100.0%
West Asia and Arabian Peninsula																	
Iraq	15	14	1					6		1		9	9		40	98	178
Jordan	20	18			2	2	2	5				8	44	8			88
Pakistan	204	55	91	26	32	7	7	53		60		61	37	40	99		561
Saudi Arabia	7	2	2		3	1	1	3		4		8	4			4	31
Syria	111	85		26		6	5	30		16	15	62	55	19	34	20	368
Turkey	128	109	4	12	3	22	9	38	43	11	28	86	229	30	5	149	769
Yemen AR	12	7		2	3			3				7	2	1	2		27
Yemen PDR	15	5		3	7			7		2		21	25	7	11		88
Subtotal	512	295	98	69	50	38	24	145	43	94	43	262	405	105	191	271	2,110
% Total Commodity Scientists	16.8%	9.7%	3.2%	2.3%	1.6%	1.2%	0.8%	4.7%	1.4%	3.1%	1.4%	8.6%	13.3%	3.4%	6.3%	8.9%	69.1%
% Total Crop Scientists	24.3%	14.0%	4.6%	3.3%	2.4%	1.8%	1.1%	6.9%	2.0%	4.5%	2.0%	12.4%	19.2%	5.0%	9.1%	12.8%	100.0%
Total	707	449	120	84	54	62	45	226	51	123	94	462	601	107	343	287	3,064
% Total Commodity Scientists	15.1%	9.6%	2.6%	1.8%	1.2%	1.3%	1.0%	4.8%	1.1%	2.6%	2.0%	9.9%	12.9%	2.3%	7.3%	6.1%	65.5%
% Total Crop Scientists	23.1%	14.7%	3.9%	2.7%	1.8%	2.0%	1.5%	7.4%	1.7%	4.0%	3.1%	15.1%	19.6%	3.5%	11.2%	9.4%	100.0%

Country	Total Food Crops	Total Non-Food Crops	Pasture/ Fodder	Animal Husbandry	Animal Health	Total Animals	Forestry	Fisheries	Total Commodity Scientists	Other*** Researchers
<u>North Africa</u>										
Algeria	19	0							19	
Egypt	197	145				411		136	1,230	2,323
Morocco	138	18	5	206	205	75	4	13	248	259
Tunisia	90	7	9	34	36	20	11	17	145	92
Subtotal	784	170	14	251	241	506	15	166	1,623	2,674
% Total Commodity Scientists	48.3%	10.5%	0.9%	15.5%	14.8%	31.2%	0.9%	10.2%		
% Total Crop Scientists	81.3%	17.8%								
<u>West Asia</u>										
Iraq	40	138	1		29	30	18	6	232	316
Jordan	80	8		14		14		3	105	10
Pakistan	422	139		175	131	306	74	64	1,005	1,495
Saudi Arabia	27	4	10	16	5	31		65	127	44
Syria	295	73	16	17		33		4	405	178
Turkey	585	184		79	110	189	66	37	1,061	569
Yemen AR	24	3		4		4	1		32	91
Yemen PDR	70	18							88	13
Subtotal	1,543	567	27	305	275	607	159	179	3,005	2,716
% Total Commodity Scientist	50,5%	18.6%	0.9%	10.0%	9.0%	19.9%	5.2%	5.9%		
% Total Crop Scientists	73.1%	26.9%								
Total	2,327	737	41	556	516	1,113	174	345	4,678	5,390
% Total Commodity Scientists	49.7%	15.8%	0.9%	11.9%	11.0%	23.8%	3.7%	7.4%		
% Total Crop Scientists	75.9%	24.1%								

* Includes expatriates, working with national systems, but not staff of International Agricultural Research Centres.

** Other crops include crop-related research (mainly for food crops) which cannot easily be attributed to an identified commodity, i.e. plant breeding, plant physiology, plant, pest and and disease control; some aspects of engineering, soil (plant nutrition), and irrigation research.

*** Scientists in national systems not specifically working on commodities.

example in Syria, Tunisia, and Turkey) show that they lack an effective central planning and coordinating mechanism, are excessively dispersed and fragmented among various Ministries and parastatal agencies, do not have a good capacity for inter-disciplinary research, tend to overload individual researchers with too many projects, and have many poorly staffed and equipped 'regional' sub-stations often with no clear regional responsibility in an operational sense e.g. located for work on a major ecological region of the country. The linkages of the public sector research staff with policy-makers 'upstream', laterally with the universities and private sector scientists at the working level, and 'downstream' to extension workers and farmers are generally commented on adversely by external reviewers, although part of the blame for this situation must rest with the inadequate funding and consequent low status of the research staff, and their lack of mobility and equipment for field level work.

Low resource allocations to work on food legumes

Data collected by IFPRI from national systems, World Bank, ISNAR and FAO reviewers, and other International Agricultural Research Institutes indicate that in terms of commodities a preponderance of scientific staff in most national systems is now being allocated to horticulture - fruits and vegetables, which together absorb 35 % of crop scientists and 26% of all commodity scientists in the region. This high allocation is true of practically all countries, presumably because of the high unit value of horticultural crops and opportunities for developing exports to Europe (Table 26).

Cereals and Pulses, despite their extremely high importance in the national diets and the fact that they occupy the major share of all rainfed land, are generally less well served. Together they represent 30% of all crop scientists and about 20% of the total commodity scientists. However in most countries the food legumes get a low share of these resources, with cereals workers outnumbering legume scientists by three or four to one. Food legume researchers represent about 7.4% of crop scientists overall and 4.8% of commodity scientists. The main exception is Egypt where pulses, especially Faba Beans are well supported. Apart from Egypt, Pakistan, Syria and Turkey have pulse programmes which are numerically fairly strong, although still a small proportion of total research effort on crops.

The low level of support for pulses is probably not out of line with the relative importance of cereals and pulses in terms of the proportion of land which they occupy, but the total research effort allocated to pulses over time both nationally and internationally has been much less. The majority of national research systems have a long history of cereal and especially wheat research, whereas nearly all pulse research programmes in WANA (and indeed in most developing countries) are relatively in their infancy.

In most national programmes legume scientists work on both food <u>and</u> forage legumes: statistics on separate pasture and fodder crop programmes, usually related to animal science research are sparse, but total recorded staff in the five countries for which data are available amount to only 0.9% of commodity scientists. This may indicate that the crucial importance of feed and fodder supply to increased productivity of livestock in the region is still not fully recognized.

Yet animal sciences as a whole are not poorly supported, their staff comprise 24% of all commodity scientists overall and 31 per cent of the total in North Africa. This is more congruent with their contribution to agricultural GDP than is the case with many other research allocations to commodities. However approximately half of all animal scientists are veterinarians.

<u>Disciplinary imbalances in scientific staff</u>

In disciplinary terms it is very difficult to obtain data on the allocation of scientists to individual commodities, many disciplinary research staff are spread across several commodities, especially on subjects other than breeding and crop protection. Broadly speaking plant sciences - breeding; various aspects of pest, disease, and weed, control, and agronomy represent 50 per cent of all disciplinary staff: natural resource management disciplines, soils, plant nutrition, microbiology, agroclimatology, and water use represent about 18 percent; farm mechanization and all aspects of post-harvest technology and processing only 4.5 per cent; all economics and social sciences (including extension methodology) only 3 per cent; animal sciences about 15 percent (within which range, pasture, and fodder crops management represents only 3 per cent); fisheries 4.5 percent and forestry only 2.3 per cent.

The weaknesses of disciplinary research on technology, processing, storage, and marketing and on economics and social sciences are particularly disturbing, since they are especially pertinent to the production and sale of horticultural crops, and livestock; and inter-related in the sense of the need for market analysis and the economics of agro-industry development. As indicated earlier such analysis is also relevant and needed with respect to all crops with export potential, such as legumes for food or feed.

A strong social science component is also necessary to complement the work of staff in biological and resource management disciplines in developing improved cropping and farming systems in the region, especially with respect to the use of fallow and the expansion of crop and livestock integration within and between ecological zones in the region. Yet few national programmes are equipped to supply this input to provide the essential financial and economic framework of analysis for their technical research, and this is very obvious from the widespread lack of such data in published reports. Not only does this compartmentalization of the various scientific disciplines contribute to failure in understanding why research sometimes does not live up to expectations, but it also hampers extension staff in advising farmers on the various options open to them in their choice of enterprises and use of resources.

5.3.2. Extension effort

Extension services in several WANA countries have been the subject of external reviews, usually by the World Bank, to provide a basis for determining the need for Bank loans to help strengthen the national system. Within the last five years the Bank has provided technical and financial assistance to Syria, Tunisia, and Turkey and opened discussions with Algeria; while UNDP has also been assisting some countries, Iraq and Syria for example, in building extension competence.

It is clear from study of these project documents that many of the weaknesses which beset research also affect extension effort; including limited financial support, lack of sufficient well-trained subject-matter staff, and a plethora of low grade village level workers, a crippling inadequacy of transportation and modern communications equipment, and a tendency to overload 'advisory' staff with administrative, regulatory, and service duties. Extension like much of the research, is generally organized to coincide with some administrative unit, (prefecture, mouhafadha, etc.), rather than on an ecological zone basis.

In the WANA region, as well as in most developing countries, there exists an acute of linkage between research and extension. Huge gaps between research stations and farmers' yields are reported throughout the region. The technology transfer process lacks impetus. Very often, the adoption of a new technology has not spread beyond farmers involved in exprimental programs, i.e. Farmer managed on-farm research (Erskine, et al. 1988). Extension remains a binding contraints to new technology adoption.

The summary of the debates of the workshop held in Tunis June 1988, on "The Role of Legumes in the Farming Systems of Mediterranean Areas" is very illutrative of the current research-extension stalemate in the region. Participants in the above mentioned workshop concluded that the extension services in WANA are not efficient. Extension agents are, all too often, not associated with the research process, not even with on-farm research. The status of extension may be an explanation of its low efficiency. In WANA, there exists a significant status bias towards research. In many other countries, especially developed countries, research and extension staff have equal status and equivalent qualifications. This may explain why extension is successful in some countries and not in others. The fallow replacement project in Turkey illustrates how fundamental is extension to new technology adoption.

ICARDA has neither the means nor the mandate to get directly involved in national extension systems. However,, it has an important role to play in training. This will ultimately improve extension efficiency. ICARDA should concentrate on training trainers who will duplicate, at national levels, the knowledge acquired. The training sessions could be held at ICARDA headquarters, e.g. concurrently with the 3-month residential training session. Follow up of the "trained trainers" and helping them to overcome difficulties they may run into is also necessary, and essential.

5.3.3. Seed production

A large number of food legume cultivars has been released by national programmes, in collaboration with ICARDA, since the early eighties. However, these new high yielding, disease resistant cultivars are not, yet, available on a large scale to farmers. There is an urgent need to replace, where appropriate, the low potential yield landraces which exhibit a high susceptibility to biotic stresses, particularly diseases. The objective of the breeder is not restricted to developing new germplasm with required characters. A large adoption of his cultivars by farmers is the ultimate reward. Seed availability is a prerequisite for cultivar adoption*. Erskine, et al. (1988, op. cit) suggest that the contraint, i.e. availability of seed, requires direct action from governments, either by encouraging the private sector to produce seeds, or by becoming directly involved themselves.

Although most countries of the region have established, since long ago, procedures and guidelines for wheat seed multiplication and production, and where important also for cotton, tobacco, and sugar beet, such systems, are either non-existent or inadequate for food and forage legumes. The impact of research on food legume production will

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* Legume seed prices are usually very high and limit adoption of new cultivars, particularly in the case of forage legumes.

be seriously hindered if the seed production system, seed supply and distribution, is not improved. In the region as a whole, certified and treated legume seeds represent only a small proportion of the seeds annually planted by farmers. Review of national seeds organizations in several WANA countries (Morocco, Syria, Tunisia, Turkey) indicate that seed availability for pulses is low, often no more than 5 or 10 per cent of requirements, and that of forage legumes is generally lower, with pasture legumes even further behind. Given the high risks of seedborne disease infections, e.g. fusarium wilt, the lack of a rigorous seed production and distribution system compounds the already overwhelming legume production constraints.

In addition it is uncommon for sale of legume seeds to farmers to be subsidized by governments, although prices paid to seed producers may occasionally be. This is true even in the case of barley, which again is rarely catered for as adequately as wheat.

These differences militate against the development of farming systems based on continuous cropping of wheat with various legumes, or barley with either lentils or forage legumes and livestock in lower rainfall ecozones. Instead they tend to perpetuate the pre-eminence of wheat and the wheat-fallow system in areas where its replacemnt would diversify land use, spread risks, and increase farm incomes from mixed cropping or integrated crop-livestock systems.

Private seed enterprises are now becoming more common in the WANA region. However private seed merchants are more likely to become involved in the production and sale of seed of hybrid corn, vegetables, and perhaps certain specialized forage crops such as alfalfa or medics; than in self-pollinated cereals or food legumes where they have no particular comparative technical or economic advantage over government organizations or even farmer entrepreneurs, and cannot exercise plant breeders rights or obtain royalties on the sale of their products.

Thus it is very important for international institutions such as ICARDA to encourage and support government efforts to build up supplies of quality seed of crops such as food legumes, and to sponsor training courses for technologists and managers, through special projects of the type currently being supported by Germany and the Netherlands. These should be directed selectively to build up scarce expertise on crops for which new varieties are being developed by ICARDA's work with national research systems.

5.3.4. Marketing constraints

Unlike cereals, food legume markets lack organization, as well as suffering from price distortion policies. In Baluchistan, Pakistan, for example, only a very limited area is devoted to lentils because, according to farmers and reseachers, there does not exist an organized lentil market where farmers can sell their grain production. Therefore, the area grown corresponds to on-farm consumption needs only. A similar situation prevails in Tunisia.

Very often, legumes are not candidates for price support policies. Prices fluctuate greatly between years of abundant supply and poor crop years. In Morocco, for example (Zagdouni and Benatya, 1987) the price of lentils fell from 4700 Dirhams/ton in the summer of 1985 to as low as 2700 Dirhams/ton the following summer. Cereal prices, on the other hand are usually guaranteed by the government and thus are not seriously affected, at least within a season. On the retail market, wheat products, e.g. bread are subsidized, whereas legumes are usually not, thus influencing consumer demand. Therefore, in general, cereals are considered less risky by farmers, i.e. they provide a more stable income stream compared with legumes. If policymakers are genuinely keen to develop food legume production, then in addition to boosting research, they will have to readjust actual price policies and eliminate price distortions which constrain the legume market.

6. Food Legume Research in ICARDA: Objectives and Resources

6.1. The Food Legume Improvement Program (FLIP)*

The ICARDA Food Legume Improvement Program (FLIP) research strategy focuses on the improvement of lentil, kabuli chickpea and faba beans, because of their importance in the WANA rainfed farming system.

FLIP plays an active role in strengthening national programs (NARS) research capabilities to develop improved genetic material and suitable production technology in order to improve and sustain the productivity of the cereal based farming system. FLIP has been helping NARS in food legume improvement since the establishment of ICARDA by providing germplasm, technical assistance and training.

Multidisciplinary ICARDA teams, involving FLIP scientists, are involved in research projects throughout the region in collaboration with national scientists. Additionally, collaboration with other research institutions is carried out, e.g. joint research work on kabuli chickpea with ICRISAT, joint research program on peas with BMZ of West Germany. Also, collaboration with centers in developed countries will be enhanced in order to benefit from innovations, in biotechnologies.

The food legume improvement research at headquarters (Aleppo, Syria) is carried out at Tel Hadya main station, and Breda, Jinderess and Lattakia in Northern Syria, as well as at Terbol, Lebanon. Research sites of NARS are also used for strategic research on development of breeding material with specific resistance to various abiotic and biotic stresses. In breeding, ICARDA is pursuing a decentralization policy whereby the production of finished cultivars will gradually become under the direct responsibility of NARS. Research work at headquarters will focus on the development of early generation segregating populations, more efficient breeding methodologies and improved screening techniques. As a result, ICARDA

* This section draws heavily on FLIP and ICARDA annual reports, 1987, and ICARDA Medium Term Plan 1990-94.

is fostering the development of subregional networks. At present, four subregional networks (cereals and legumes) have already been established: Nile Valley, Arabian Peninsula, North Africa and Balluchistan (Highlands, Pakistan). Four FLIP scientists are currently with outreach programs (three of whom are in Morocco**, i.e. North Africa subregional network).

Research Program

The main objective of FLIP is to spearhead a research thrust to improve the productivity of the three main legume species in the region. This requires:

- Collection, maintenance and evaluation of a large diversity of germplasm.
- Development and distribution, to NARS, of genetic material having the required characteristics to suit the environment, e.g. high grain and biological yield potential and yield stability, resistance to diseases and pests, tolerance to moisture and heat stress, plant architecture to improve mechanical harvesting, etc.
- Upstream research (genetics, cytogenetics, physiology, ...) as a support to genotype development.
- Development of crop management practices integrating agronomy (tillage and seedbed preparation; fertilizer use; weed management; mechanization), pathology, entomology, microbiology (BNF), etc.
- Development and implementation of food legume training programs for NARS scientists (at ICARDA, regional and/or national levels) and dissemination of scientific and technical information through workshops, conferences, publications, etc.

In accordance with its global objective FLIP has identified research priorities for the three major food legumes species of its mandate.

Lentils

A high and stable crop productivity is the main program target. A

* The two faba bean scientists (a breeder and a pathologist) who have been transferred to Morocco are included.

major impediment to lentil production is undoubtedly the high costs of manual harvesting. Therefore, one of the priorities of the program is to seek most appropriate means of lowering harvest costs. To cope with this problem, FLIP is adapting a three-way approach including:

- Breeding: Develop cultivars with required characteristics such as reduced pod-drop and dehiscence, reduced lodging and better plant architecture, i.e. tall genotypes with pods born higher off ground.
- Agronomy: Mechanical harvesting is considerably facilitated if adequate seed-bed preparation techniques are applied, e.g. flat seed-bed. Fertilizer use and weed management also contribute to alleviate the problem.
- Testing appropriate machinery, e.g. double knife cutter bar, standard bean cutter, combine harvester, puller, etc., in order to identify most appropriate alternatives to hand harvesting in accordance with the specific physical environment (hills, stony fields, flat fields,..) and farmers' target groups (large vs small farmers, for example).

Results achieved through this approach are actually moving to the on-farm trial demonstration phase.

Lentils are also grown in high elevation areas, e.g. Turkey, Pakistan, Morocco, Algeria, Iran, etc. Screening for cold tolerance is crucial for such environments. Collaborative trials with the Turkish national program are already showing promising results.

Sources of resistance to pests (mainly orobanche) and diseases (mainly rust and rootrot/wilt) are being sought to improve the ability of the lentil crop to withstand pest and disease aggressions.

Studies on the adaptation of lentils have been initiated with the University of Reading, UK. A collaborative research program in Egypt, Sudan, Ethiopia and Pakistan, aiming at developing adapted cutlivars to these environments, is also underway.

Another component of the lentil program is crop quality. It mainly deals with maintaining adequate nutritional and cooking quality levels, hulling, as well as straw quality.

Physiological studies on drought resistance, cold tolerance, growth habit and adaptation are also emphasized.

<u>Chickpeas</u>

As previously mentioned, the chickpea (kabuli chickpea) program at ICARDA is a joint program with ICRISAT. Substantial productivity gains have been achieved through winter sowing chickpea. Highly promising material with relatively good cold tolerance have already been released (see Table 27 page 117). National programs, in collaboration with ICARDA, are placing major emphasis on the development and selection of material adapted to winter sowing.

Broad based resistance to ascochyta is also an important objective as different biotypes of the pathogen have been identified in the region, thus implying the presence of different physiological races. Research on wilt is also undertaken. Winter sowing chickpea also requires more emphasis on: Orobanche and weed control, the two major insect pests, i.e. pod borers and leaf miners, as well as root-knot and cyst nematodes. Considerable research efforts are also devoted to screening for cold tolerance and the identification and development of suitable strains of rhizobium. Agronomy work is mainly concentrating on large scale trials-demonstrations on the production package of winter sown chickpea, including mechanical harvesting.

<u>Faba beans</u>

Research concentrates on the removal of constraints imposed by diseases, mainly chocolate spot and ascochyta blight on the level and stability of faba bean productivity. Orobanche control, through identification of sources of resistance and development of appropriate alternative control measures, e.g. integrated control through use of chemicals and crop management techniques (delayed sowing) also constitutes a major research activity. The latter has been conducted

Table 27. Food-legume cultivars released by different national program.

Country	Cultivars released	Year of release	Specific features
Kabuli Chickpea[1]			
Algeria	ILC 482	1988	High yield, wide adaptation
	ILC 3279	1988	Tall, high yield
Cyprus	Yialousa (ILC 3279)	1984	Tall
	Kyrenia (ILC 464)	1987	Large seeds
France	TS1009 (ILC 482)	1988	Released by TOP SEMENCE
	TS1502 (FLIP-81-293)	1988	Released by TOP SEMENCE
Italy	Califfo (ILC 72)	1987	(Verbally informed, details
	Sultano (ILC 3279)	1987	expected)
Morocco	ILC 195	1987	Tall
	ILC 482	1987	High yield, wide adaptation
Oman	ILC 237	1988	High yield
Portugal	Elmo (ILC 5566)	1989	High yield
	Elvar (FLIP 85-17C)	1989	High yield
Spain	Fardan (ILC 72)	1985	Tall, high yield
	Zegri (ILC 200)	1985	Mid-tall, high yield
	Almena (ILC 2548)	1985	Tall, high yield
	Alcazaba (ILC 2555)	1985	Tall, high yield
	Atalaya (ILC 200)	1985	Mid-tall, high yield
Sudan	Shendi (NEC 2491/ILC1335)	1987	High yield
Syria	Ghab 1 (ILC 482)	1986	High yield, wide adaptation
	Ghab 2 (ILC 3279)	1986	Tall, cold-tolerant
Tunisia	Chetoui (ILC 3279)	1986	Tall
	Kassab (FLIP 83-46C)	1986	Large seeds, high yield
	Amdoun 1 (Be-sel-81-48)	1986	Large seeds, type
Turkey	ILC 195	1986	Tall, medium seed, cold tolerant
	Guney Sarisi 482 (ILC 482)	1986	High yield, wide adaptation
Lentil			
Australia	ILL 5750	1989	High yield
Algeria	Syrie 229	1987	High yield, good seed quality
	Balkan 755	1988	High yield, good seed quality
	ILL 4400	1988	High yield, good seed quality
Canada	Indianhead (ILL481)	1989	High yield of green manure
Chile	Centinela (74TA470)	1989	Rust resistant, high yield
Ecuador	INIAP-406 (FLIP 84-94L)	1987	Rust resistant, high yield
Ethiopia	ILL 358	1984	Rust resistant, high yield
Lebanon	Talya 2 (78S 26013)	1988	High yield, lodging resistance
Syria	Idleb 1 (78S 26002)	1987	High yield, reduced lodging
Tunisia	Neir (ILL 4400)	1986	Large seeds, high yield
	Nefza (ILL 4606)	1986	Large seeds, high yield
Turkey	Firat '87 (75Kf 36062)	1987	Small seeds, high yield
Faba bean			
Iran	Barkat (ILB 1269)	1986	Large seeds, long pods, high green-pod and dry-seed yield
Portugal	Favel (80S43977)	1989	High yield

1) All chickpeas are resistant to ascochyta blight and released for winter sowing, with the exception of Amdoun 1 which is resistant to fusarium wilt and released for spring sowing, and Shendi which is intended for use under irrigation. In Turkey, ILC 482 is released for spring sowing.

Table 28. Chickpea and lentil cultivars identified for pre-release multiplication.

Kabuli chickpea	
Algeria	FLIP 84-145C, FLIP 81-293C, FLIP 81-57W
Cyprus	FLIP 85-10
Egypt	ILC 200, ILC 482
Jordan	ILC 482, ILC 3279
Iraq	FLIP 81-269C, FLIP 82-142C, FLIP 82 169C, ILC 482, ILC 3279
Lebanon	FLIP 85-5, ILC 482
Morocco	FLIP 81-293C, FLIP 82-91C, FLIP 82-92C, FLIP 82-127C, FLIP 82-128C, FLIP 82-161C, FLIP 84-145C
Syria	FLIP 82-150C, FLIP 84-15
Tunisia	FLIP 84-92C, FLIP 84-15C
Turkey	FLIP 85-13C, FLIP 85-14C, FLIP 85-15C, FLIP 85-60C, FLIP 83-31C, FLIP 83-77C
Afghanistan	ILC 260, ILC 482, ILC 3279
Lentil	
Mediterranean region	
Iraq	78S26002, 78S26013
Jordan	Jordan 3
Lebanon	FLIP 84-76L
Morocco	ILL 4605
Spain	2 lines
Syria	78S26013
Tunisia	FLIP 84-103L
High elevation area	
Turkey	1066-1
S. Latitudes	
Egypt	ILL 4605
Nepal	ILL 2578, ILL 4402, ILL 4404
Pakistan	ILL 2573, ILL 4605
Others	
China	FLIP 87-53L

in collaboration with the Egyptian national program. Giza 402, released by the Egyptian national program, is considered as the first Orobanche, tolerant faba bean cultivar. Extensive agronomy studies in projects such as the Nile Valley Project (Sudan, Egypt, and Ethiopia) have led to improved production techniques.

Following the CGIAR recommendation to phase out the faba bean program, the latter has been transferred to Morocco and will operate from there starting the coming season. The faba bean collection will be maintained at ICARDA, by the Genetic Resource Unit. ICARDA activities regarding this program will deal mainly with the establishment of research facilities, the transfer of screening techniques and of breeding material to Morocco for evaluation and use by the national programs of the North Africa sub-region far developing suitable cutlivars. In that regard, a research network including varietal improve improvement, agronomy, BNF and integrated management, will be developed.

MAJOR ACHIEVEMENTS

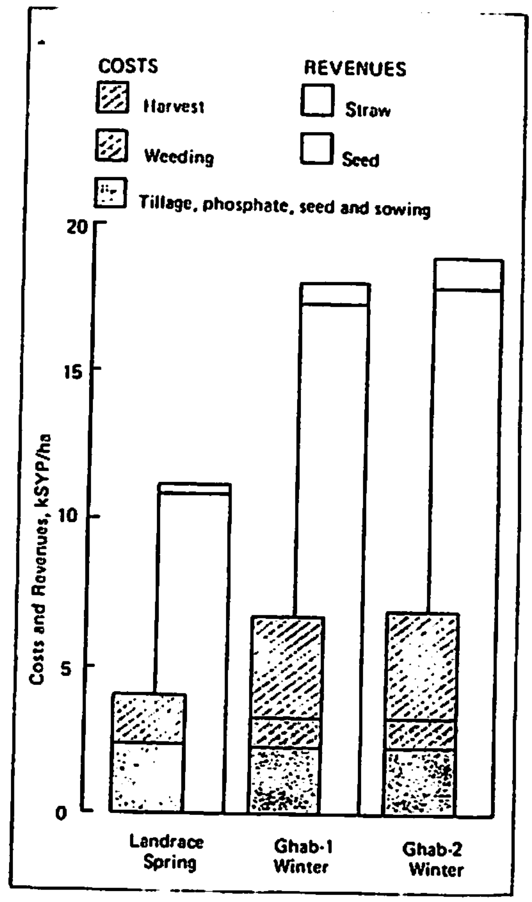
FLIP has been able to make significant advances in chickpea (kabuli type), lentils and faba beans and in developing a strong cooperative training and research program with NARS. Germplasm enhancement work has been very productive, particularly for chickpeas and lentils. Numerous improved cultivars have been released (or are being considered for release) in the WANA region and countries extending from Latin America to the People's Republic of China (see Tables 27 and 28).

The advances made in chickpeas research (development of winter sown cultivars with resistance to ascochyta blight and cold tolerance) are expected to increase farmers' yields as on-farm trials have shown possible increases in yield of up to 100% (Figure 5).

Similarly, the release of lentils cultivars with appropriate architecture and required traits (resistance to shattering, pod indehiscence) for mechanical harvesting constitutes but the early payoff of the considerable research effort, much more is to come.

Faba bean research has also led to improvements of yield and yield stability by national programs.

Figure 5. Chickpea cultivars sown in winter double the profit to Syrian farmers.



Source: ICARDA-Annual Report 1987, P. 22.

In the field of biological nitrogen fixation, a simple method involving yield comparison of symbiotic plants wholly dependent on nitrogen fixed with native rhizobia, and plants fully supplied with adequate amount of nitrogen to produce high yields, was developed. Strong positive correlations were found, over a range of cultivars in multilocation trials, in terms of nitrogen and inoculation responses, in chickpeas, lentils and faba beans. Sets of highly effective and competitive rhizobia strains were obtained through strain selection. Results of inoculation trials, using best strains, show that average yield increases, across 12 cultivars of chickpeas, lentils and faba beans, were 13, 14 and 15%, respectively. These results suggest a potential role for inoculation in improving legume production.

Lentil research has sought to remove factors hindering mechanical harvesting, such as:

- high tendency to lodging.
- plant height (short stature)
- pod dehiscence and shattering. No genetic variability has been found for shattering. Pod indehiscence is, however, a heritable trait. Delaying harvest time is a method used for selecting for indehiscence. The new cultivars have demonstrated both reduced lodging and reduced shattering in mechanical harvesting on-farm trials. Combined with better crop management techniques and resistance to biotic stresses, these improvements in plant characteristics are bringing lentil research closer to the fulfillment of its objectives.

<u>The strengthening of food legume national programs is another major achievement</u>. In the late seventies national capacities in food legume research were weak, at best. Over the last decade, FLIP has launched an extensive training program that has involved more than 600 legume scientists and technicians in field areas ranging from agronomy, breeding, plant pathology, etc. (Table 29). As a result of this considerable training effort food legume national research programs have been fully established in countries where none existed just few years ago. In order to enhance collaborative research, an International Food Legume Testing program has been set up to distribute improved genetic material for testing by national programs. the network approach developed by the Nile Valley Project (faba beans) is widely considered as a successful model. The networking strategy of ICARDA has been largely inspired by this successful collaborative program.

Table 29. Summary of training courses in 1988.

Type of training and topics	No. of Participants	No. of countries Represented
Training courses at Aleppo		
1. Group courses	41	14
1.1. Residential		
1.2 Insect control		
1.3. Disease methodologies		
1.4 Lentil harvest mechanization		
2. Individual non-degree	21	7
2.1. Microbiology		
2.2. Agronomy		
2.3. Entomology		
2.4. Pathology		
2.5. Data processing		
2.6. Mechanization		
3. Individual degree	7	4
3.1. Orobanche control		
3.2. Quality		
3.3. Breeding		
3.4. Agronomy		
3.5. Physiology		
In-country training courses	101	6
1. Crossing techniques (Tunisia)		
2. Hybridization techniques (Turkey)		
3. Legume Improvement (PROCIANDINO, Ecuador and Colombia)		
4. Field experimental (Morocco)		
5. On-farm trials (Ethiopia)		

6.2. Balance among Research Programs at ICARDA

6.2.1. Current and projected resource allocations to research programs

The estimated allocation, by the second EPR Panel, of research effort across ICARDA Programs indicates that food legumes received 31% of the total research effort. The cereal program received 26%, whereas PFLP and FRMP together received 43%. These research efforts were then related to the estimated share of the respective commodities in the value of output, resulting in what is called "research intensity ratios". The latter were evaluated at 0.8, 7.6 and 0.7 for cereals, food legumes and production systems, respectively (a perfect congruence between resource allocation to research and product value would be 1.0). Based on these research intensity ratios, the EPR panel indicated that expected gains from food legume research should be almost 10 times and 12 times greater than the gains from cereals and production systems, respectively, in order to justify ICARDA's current resource allocation to food legumes. This analysis holds good only if one looks at the aggregate food legume research effort and value of production. Moreover it is an exercise in comparative statics, and takes no account of future potentials. Table 30 below shows the allocation of resources within FLIP. The lentil research effort amounted to less than 5% in 1989. Assuming an estimated (lentil) share of 1.5% in the value of expected total output, the lentil research intensity ratio would be 3.15%, which is well below the 7.6% figure (in the EPR document, page 67) for aggregate food legumes. The ratio will probably decrease since the ICARDA medium -term plan 1990-94 projects an average annual growth rate of -7.0% for food legume program budget by the year 1994, whereas all other programs have a positive growth rate (Table 31). By 1994, FLIP staff will represent less than 20% of ICARDA's research programs staff, compared with 31% in 1988 (Table). On the other hand, the FLIP budget share is expected to decrease from 27.4%, of ICARDA's research programs budget, in 1989 to 15.3% in 1994 (Table 32).

Table 30. Allocation of core budget resources within FLIP, including two positions from ICRISAT.

	FLIP 1988 budget allocation in '000 US $	1988 Budget share (%)	FLIP 1989 budget aloocation in '000 US $	1989 Budget Share (%)	Share in ICARDA 1989 Research programs budget (%)
- Faba Bean Improv.	693	26.7	489	16.5	4.46
- Lentil Improv.	454	17.5	518	17.5	4.73
- Chickpea Improv.	714	27.5	963	32.5	8.79
- Net working and Training	734	28.3	992	33.5	9.06
Total	2595	100.00	2962	100.00	27.04

Source: ICARDA Program of work and Budget 1989, pages 58 and 100.
ICARDA Medium-Term Plan 1990-94 Page 169.

Table 31. Research Programs staff projections for 1994.

	1988	1989			1990			1991			1992			1993			1994			Ave.Ann.change (%)	
	core	E	D	T	E	D	T	E	D	T	E	D	T	E	D	T	E	D	T	E	T
Farm Res. Management	61	60		60	60		60	71	5	76	71	13	84	71	17	88	71	20	91	3.7	10.3
Cereal Improvement	68	76		76	72		72	74	2	76	74	2	76	72	8	80	69	8	77	-1.9	0.3
Food Legume Impr.	81	73	1	74	61	1	62	53	4	57	52	5	57	47	8	55	45	14	59	-7.7	- 4.1
Pasture, Forage, and Livestock	49	50		50	55		55	57	2	59	59	5	64	59	6	65	62	8	70	4.8	8.0
FLIP share (%)	31.2			28.4			24.9			21.2			20.2			19.1			19.8		
Total	259	259	1	260	248	1	249	255	13	268	256	25	281	249	39	288	247	50	297	-0.9	2.9

Table 32. Evaluation of research programs budget 1989-1994 (in '000 US $)

	1989 TAC Approved	19894 Actual	1990	1991	1992	1993	1994	Average Annual Growth (%)
Farm Res. Management	2,230	2,345	2,393	3,870	2,791	2,945	2,927	6.2
Cereal Improvement	2,890	3,452	3,446	3,750	3,867	3,767	3,801	6.3
Food Legume Impr.	2,705	2,962	2,571	2,270	2,229	1.807	1,754	-7.0
Pasture, Forage, and Livestock	2,040	2,193	2,429	2,429	2,636	2,709	2,945	8.9
FLIP share (%)	27.4	27.5	23.7	20.0	19.3	16.0	15.3	
Total	9,865	10,952	10,820	11,319	11,523	11,228	11,427	3.2

Source: Medium-Term plan 1990-94 consolidation and change ICARDA. Sept. 1989.

The EPR analysis of research resource allocations to food legumes is, therefore, misleading in failing to account from imbalances <u>within</u> the program. In 1989, for example, less than US $ 520,000 were allocated to lentil work compared with US $ 963,000 for chickpeas (Table 30). The distribution of special project funds, among and within programs, is also illustrative of the bias imposed by an aggregated approach. Out of a total of 66 projects, 23 are devoted to food legumes (35%). However, <u>none</u> of these projects deals specifically with lentils (Table 33).

Proposals for research collaboration between ICARDA's research programs also indicate the existence of imbalances to the detriment of food legumes, in general, and lentils, in particular, even though ICARDA has the world mandate for lentils. For example, the resource allocation and priorities of the Farm Resource Management Program, reveals that research on the management of soil, water and nutrients constitutes the principal research activity. Within this activity, the highest priority is placed on research on the barley-livestock systems in the dry areas of the WANA region (Table 34). The aim of this research is to develop technology for sustained improvement in livestock feed supply through increased barley production and fallow replacement with forage and pasture legumes (ICARDA, Program of work and budget, 1989-Page 45). There does not seem to be any "direct" mention of food legumes, in contrast to forage legumes, in FRMP research priorities. We assume that some of the work under the heading of wheat-based systems will involve food legumes in cropping systems with wheat, but this is not explicit in the "Programme of Work and Budget, 1989" document. Therefore, we must conclude that, as already mentioned by the second EPR panel, most of the research collaboration of FRMP is with PFLP, and to a lesser extent with CIP, rather than with FLIP.

Table 33. Special projects: Distribution among crops and programs - ICARDA, 1989

	Wheat	Barley	Cereals	Farms Res. Agr.Prog.	Pastures Forages	Faba Beans	Chickpeas	Lentils (1)	Food Legumes	Others
Special Funded Projects	xx	xxxx	xxxx xx	-	-	-	xx	-	xxx	xxxx(2) x
Collaborative research Projects with advanced institutions	xxx	xxx	xxxx x	x Barley x Food leg. x Livestock x Barley	xxxx xxxx xx	xxxx x	xxxx xxx	-	xxxx x	x (3)

x = One Project

(1). Restricted core support (1987-89) from CANADA (IDRC) for lentil information service (Lens newsletter) is not included.

(2). These include: MART/AZRI Project, Pakistan; Seed production; virology; Training of Arab participants in ICARDA residential training courses; Cooperative projects with Canadian Universities (IDRC).

(3). Weed control and water use efficiency in peas.

Source: Constructed from "ICARDA's Program of Work on Budget, 1988", pp: 77-96.

Table 34. Allocation of Resources and Relative Priorities 1/ of FRMP.

	Actual & Projected Allocation of Core Budget % 1988	1989	Native Pastures and Steppeland	Barley/ livestock Systems	Wheat based systems	Irrigated Agric. Systems
Management of soil,Water and Nutrients	46.0	41	x	xxxxx	xxx	-
Agroecological Characterization of Resource Management	15.3	20	xx	xxxx	xxxx	-
Adoption and Impact of New Technology	9.4	12	x	xxx	xxxx	x
International Collaboration 2/	11.0	12				
Training 3/	7.2	7				
Administration (Program Leader's Office)						

1/ Relative priorities will remain the same in 1989.
2/ Core contributions to specially funded projects in Syria and Tunisia, both due to end in 1989.
3/ Training is given in methods of applied farming systems research and specific aspects of resource management which are equally applicable to all four broadly defined agricultural systems.

Source: ICARDA Program of Work and Budget, 1989 - Page 47.

6.2.2. Assessment of imbalances in ICARDA's research portfolio in the light of needs

We have remarked earlier on the second EPR panel's comment that in order to justify current research balance at ICARDA, expected gains in productivity from food legume research should be 10 to 12 fold greater than expected payoffs from cereals and production systems*, respectively. As noted by the panel itself, it is highly improbable that such gains could be achieved in the foreseeable future by food legume research.

However, considering total output only may overlook the positive effects of legumes on the farming system as a whole. One of these effects is the nitrogen-fixing capacity of legumes. Regarding this issue, the comment of the panel was that"... such contribution, independent of ICARDA's research, would continue if farmers consider the residual effect to be of real value". This argument is valid only to a certain extent. Most farmers of the region are convinced of the positive effects of legumes on the farming system. However, quite often they are forced to reduce their legume area or switch to other crops because of unstable prices, high production costs, or important production problems, e.g. orobanche in faba beans and lentils, fusarium wilt and ascochyta diseases, the sitona weevil, plant architecture not adapted for mechanical harvesting, high yield losses due to pod dehiscence and shattering, etc. The removal of these production constraints is the main focus of research at ICARDA. The negative effects of current production constraints on farmers' behavior, vis a vis legume crops, will gradually vanish as advances in research are achieved. This in turn, given the demand for pulses, is likely to lead to a much bigger share of food legumes in the rotation, thus improving their contribution to more productive and sustainable cropping systems. It is clear that, in the WANA region, ICARDA's research is the driving force of such a process. The very promising results of the winter chickpea technology constitute one of the early payoffs that can be expected from potential advances in food legume research.

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* FRMP and FLIP are lumped under this denomination by the Panel.

In its report (page 68) the second EPR panel suggested that "Potential advances should be made available by some institutions, not necessarily ICARDA". It is obvious that in the WANA region there is no other research institution, be it international, regional or national, that has a comparative advantage over ICARDA in food legume research. The national food legume programs are relatively "young"[1], understaffed, and not yet well organized, e.g. Algeria, Morocco, Syria, Jordan and to a lesser extent Turkey, Pakistan and Tunisia. For example, it was indicated that less than three years ago, in both Algeria and Morocco research on food legumes, by national programs, was "insufficient, fragmented, uncoordinated and in some cases lacks direction and continuity"[2]. All national programs of the region continue to heavily rely on ICARDA for germplasm, technical assistance, training[3] and access to laboratory facilities.

In the WANA region, cereals, livestock and forage legumes have all benefited (and still benefit) from a relatively larger research input compared to food legumes, through the work of various other institutions, e.g. CIMMYT for cereals and medicago, CSIRO and ACIAR (Australia) for medicago and subclover, ACSAD for cereals and livestock, FAO for cereals, livestock and medicago, not to mention numerous bilateral projects with European donors, particularly in North Africa[4], and US institutions.

The "research intensity ratios" used in the EPR report do not seem to take into account the very high "research efforts" of all the other

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* When ICARDA started, there was a virtual vacuum in food legume research in the WANA region (FLIP - Annual Report - ICARDA, 1987).

** M.B. Solh, ICARDA strategy for food legume improvement in North Africa, ICARDA, revised October, 1988.

*** In this regard, it is worth mentioning that 33% of the food legume program budget was allocated to training and networking activities in 1989. The other programs allocations were: cereals 21%; farm resource management 20%; and pastures, forages, and livestock 15%.

**** In Morocco, for example, projects with CIMMYT, ACSAD, ICARDA, EEC, USAID, Italy and the World Bank all deal with cereal production. Other projects dealing with livestock production and farming systems also exist (Faraj, 1988).

institutions that have contributed (since the early sixties), to the current higher shares of cereals and small ruminants output relative to total value of production in the region.

Expected potential gains in productivity from research investment are an important factor in resource allocation decisions.

In dry environments, the cereal productivity curve seems to have levelled off. It has been indicated that under these environments, the contribution of genetic improvement to total yield gains is low (20-35%), and that the gains in productivity have been modest over the past two decades (1987-88 CIMMYT world wheat Facts and Trends. pp. 12-13). For legumes, however, because of past neglect, there has been a limited invstment in genetic improvement, especially by national programs. Therefore, the contribution of breeding (better plant architecture, resistance to biotic stresses, e.g. diseases, etc.) to total yield gains is expected to be much higher, compared with cereals. Winter chickpea technology (resistance to ascochyta blight and fusarium wilt, and tolerance to cold) illustrates the potential gains in productivity (yield may be increased by up to 100%) that can be achieved through legume breeding.

Legumes (food and forage) play an important role in the improvement of productivity and in the sustainability of rainfed farming systems. However, Jones (1988, op cit.) has indicated that the share of forage legume area, relative to the rainfed cultivated area, has decreased from 10-15% in the 1950's to as low as 2% in Syria, for example. Citing the work of Stern, Buddenhagen (1988) has also indicated that the legume content of Australian pastures is less than that of 25 years ago, and is now disturbingly low. This indicates that there is also a need for a strong forage legume research program. Forage research at ICARDA is currently more focused on intensive systems based on medic-wheat rotations, i.e. zones of 350 mm of annual rainfed and above, which constitute the wheat-based farming system. Work initiated in the region since the early 1970's, e.g. CIMMYT in North Africa, has demonstrated the great potential of such a cropping system. However, so far, farmers' adoption of this system has been very limited in the region.

The development of forage legume species well adapted to the barley-based system that demonstrably out-produce barley, in the continuous barley system, and fallow, in the fallow-barley system, coupled with rangeland improvement and prophylactic programs will likely yield higher gains in animal productivity.

<u>We conclude that as shown in tables 33 and 34 above, a "real and serious imbalance in the centers' current research portfolio" indeed exists, to the detriment of food legumes and lentils</u>. We therefore urge that the overall allocation of resources among research programmes should be reassessed by ICARDA's Management and Board in the light of the phasing out of the faba bean program which accounts for a large proportion of the total FLIP budget. If an obvious imbalance is still seen to exist, then further adjustments, may have to be made, but these should not extend to shutting down the lentil program altogether. This, we feel, would be an unproductive decision, to say the least, especially as other options appear to exist.

For example, pooling research activities, particularly agronomy, pathology and microbiology, so that they encompass both food and forage legumes[1] would probably lead to substantial economies of scale. There is no apparent reason why vetch and lentil agronomy, for example, should not be handled by a single team of scientists. Whether this agronomy team wears a FLIP or a PFLP cap is a trivial consideration. Such adjustments do not involve a major reorganisation of ICARDA's structure and could be made expeditiously.

Economies of scale are also likely to be gained through food legume networking, particularly in North Africa. Whenever possible, this research approach should be emphasised. A prerequisite of such a strategy is the zoning of problems to be tackled in order to avoid redundancy and waste of limited resources.

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* "It seems that the only clear distinction between forage and food legumes lies in the mode of their utilization in any particular situation". On the other hand, research lentil mechanization, for example, seems likely to have applications either to food or to forage legumes grown to maturity, e.g. vetch. (Jones, 1988, op cit.).

Legumes have a natural niche in WANA dry environments, characterized by a very variable and fragile resource base. Legume research is relatively new compared to cereal research, for example[1]. In the face of growing food deficits, policy makers are putting more emphasis on the gradual reduction of fallow (which occupies, in some countries, up to 50% of the rainfed cultivable land)[2], and production sustainability through the gradual elimination of the cereal - cereal cropping system. In either case, food and/or forage legumes constitute the main alternative crops.

However, except for Turkey, net returns per unit area are generally low for legumes because of low yields and high costs of production. This is due to production constraints that research has not yet addressed satisfactorily because of past neglect. The development of varieties with high and stable yields, resistant to diseases and with an appropriate plant habit, i.e. upright stand resistant to lodging and to pod shattering[3], will considerably improve legume productivity and profitability. A large proportion of production costs is embodied in the high labor costs of harvest. As mechanical harvesting becomes a sound, technical and economical, alternative, food legume production costs should decline, thus improving net returns from these crops. National legume programs of the region, because of their short experience, have neither the means nor the comparative advantage of tackling such complex breeding and production problems: ICARDA does.

The next decade is very crucial for most countries of the region

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* In addition, most national legume programs are understaffed, have undertrained staff that usually deal with both food and forage legumes, and exhibit low staff stability, i.e. high turnover. (In Tunisia, Morocco and Algeria, most of the scientists who started the program are in training overseas).

** As indiated in section 4 above, this experience was very successful in Turkey where up to 2 million hectares of fallow are now occupied by legumes. However, little progress has been achieved elsewhere despite increases in output prices, e.g. Algeria.

*** This is particularly important for the improvement of mechanical harvesting performance as it leads to yield loss reduction.

(high population growth, negative trade balance, growing food deficits). If the legume program is phased out, then to hope for much progress in food legume research in the region will be utopian, to say the least. <u>Any decision on the future of the legume program at ICARDA, should, therefore, take into consideration the direct and indirect beneficial effects of food legumes on the farming system as a whole and not solely their (direct) share in total output; not to mention the expected effects of such a decision on the future of national programs</u>.

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Annex Table 15

AREA, PRODUCTION AND YIELD

CANADA

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	Annual Av Growth Rt 1973-88	Annual Av Growth Rt 1973-79	Annual Av Growth Rt 1973-79
LENTILS																						
AREA ('000 ha)				6.1	0.3	0.2	0.2	1.2	0.5	12.1	25.1	34.4	50.6	36.0	52.6	60.7	108.1	202.4	121.5	42.27 **	38.12	22.73 **
PROD ('000 t)				3.4	0.1	0.1	0.2	1.4	9.2	8.6	13.6	38.1	68.0	45.4	24.9	46.3	145.1	263.1	45.5	44.33 **	49.69	20.26 *
YIELD(kg/ha)				560	448	522	895	1119	1080	711	542	1107	1343	1232	473	762	1342	1300	374	2.06	11.57 *	-2.48
PRICE($/kg)				14.99	44.40	36.66	44.44	77.78	33.33	48.39	66.81	44.09	33.07	33.07	40.79	66.14	47.40	26.46	30.86			
WHEAT																						
AREA ('000 ha)	2226.7	4467.2	4534.4	5425.1	4898.8	4898.8	5991.9	5951.4	5708.5	5991.9	5991.9	6417.0	6680.2	7186.2	6599.2	6659.9	7024.3	6376.5		3.91 **	7.44 **	0.94
PROD ('000 t)	3919	8129	7185	8872	6967	8437	12601	11757	11294	8736	9253	11961	13793	13017	9607	10968	14941	12002		4.37 **	0.81 **	2.31
YIELD(kg/ha)	1760	1820	1585	1635	1422	1722	2103	1975	1978	1458	1544	1864	2065	1811	1456	1647	2127	1882		0.46	0.57	1.37
PRICE($/kg)	0.05	0.05	0.06	0.16	0.15	0.13	0.10	0.10	0.14	0.18	0.21	0.19	0.17	0.18	0.18	0.13	0.11					

Prices of Cereals and Legumes in Algeria, 1979-1988 (Algeria d/kg)

Year	Lentils	Chickpea	Broad Beans	Peas	Durum	Bread Wheat	Barley
1979	2.90	2.40	1.70	1.90	1.20	1.10	0.80
1980	2.90	2.40	1.70	1.90	1.20	1.10	0.80
1981	2.90	2.40	1.70	1.90	1.20	1.10	0.80
1982	3.00	3.00	1.70	1.90	1.40	1.30	0.80
1983	3.30	3.30	2.00	2.20	1.60	1.50	1.00
1984	3.30	3.30	2.00	2.20	1.60	1.50	1.00
1985	4.30	4.30	2.70	2.90	2.00	1.90	1.40
1986	5.00	5.00	2.95	3.20	2.20	2.10	1.55
1987	6.00	6.00	3.25	3.50	2.70	2.20	1.70
1988	7.20	7.20	3.25	3.50	3.20	2.50	1.90

Annex Table 17

Prices of Legumes in Tunisia, 1972-1988 (d/t)

Year	Lentils	Chickpeas	Broad Beans	Peas	Durum	Bread Wheat	Barley
1972	No data	90.50	87.90	9.50	48.00	43.00	28.00
1973		90.20	92.90	9.50	48.00	43.00	28.00
1974		90.20	105.40	12.30	61.00	55.00	40.00
1975		94.50	70.90	12.30	66.00	60.00	45.00
1976		64.00	90.00	13.00	66.00	60.00	45.00
1977		120.00	95.00	13.00	71.00	65.00	50.00
1978		180.00	95.00	13.00	76.00	70.00	55.00
1979		170.00	95.00	13.00	76.00	70.00	55.00
1980		180.00	100.00	15.00	86.00	77.00	59.00
1981		180.00	100.00	18.00	96.00	87.00	69.00
1982		300.00	250.00	20.00	110.00	100.00	80.00
1983		400.00	350.00	20.00	128.00	117.00	95.00
1984		600.00	400.00	20.00	140.00	140.00	100.00
1985		700.00	450.00	25.00	150.00	145.00	105.00
1986		800.00	500.00	25.00	160.00	160.00	110.00
1987		750.00	251.00	25.00	185.00	170.00	120.00
1988		828.00	279.00	25.00	210.00	190.00	140.00

Prices of legumes and Cereals
in Morocco, 1970-1988
(dh/kg)

Year	Lentils	Chickpeas	Broad Beans	Peas	Durum	Bread Wheat	Barley
1970					0.44	0.40	0.26
1971					0.47	0.44	0.28
1972					0.47	0.44	0.28
1973					0.49	0.45	0.29
1974					0.63	0.60	0.40
1975	0.97	1.24	0.69	0.61	0.63	0.60	0.40
1976	1.59	1.08	0.94	1.24	0.63	0.60	0.40
1977	1.70	2.40	1.01	1.03	0.85	0.85	0.65
1978	1.87	2.03	1.06	1.13	0.85	0.85	0.65
1979	2.19	1.53	1.43	1.83	1.05	1.05	0.80
1980	2.52	2.34	2.00	2.43	1.25	1.25	0.90
1981	3.67	2.65	5.70	2.15	1.35	1.35	0.96
1982	3.97	2.80	1.60	1.92	1.40	1.40	1.00
1983	3.70	4.15	1.92	2.73	1.40	1.40	1.00
1984	2.95	3.60	1.88	2.38	1.50	1.50	1.10
1985	2.45	2.68	1.61	1.78	1.80	1.80	1.50
1986					2.00	2.00	1.65
1987					2.00	2.00	1.65
1988					2.00	2.00	1.65

Prices of Legumes
in Syria, 1979-1989
(SL/Kg)

Year	Lentils	Chickpeas	Bread Wheat	Durum Wheat
1979*	0.80	2.50	0.65	0.70
1980	1.10	2.50	0.70	0.80
1981	1.20	2.50	0.95	1.05
1982	1.51	2.60	1.19	1.32
1983	1.60	2.62	1.23	1.38
1984	1.60	2.62	1.23	1.38
1985	1.80	3.00	1.23	1.38
1986	1.80	3.00	1.90	1.50
1987	6.00	7.00	2.50	2.60
1988**	8.00	9.00	3.50	3.75
1989	9.00	10.00	5.10	5.75

Source: * MAAR, The Annual Agricultural Statistical Abstract
** Provided by A. Mazid

Prices of Cereals and Legumes in Turkey, 1979-1988 (tl/kg)

Year	Green Lentil	Red Lentil	Chickpeas	Wheat	Barley	Rye	Oat	Corn	Paddy
1979	18.00	9.00	25.00	5.03	4.80	4.70	4.60	9.00	19.00
1980	38.00	26.00	30.00	10.23	9.00	8.50	8.50	11.00	33.00
1981	57.00	42.00	44.00	18.75	14.00	13.00	12.00	17.00	51.00
1982	63.00	52.00	53.00	22.95	16.00	15.50	14.00	23.00	61.00
1983	68.00			29.00	22.00	18.00	17.00	26.00	65.00
1984		60.00		46.80	44.00	46.00	44.00	55.00	100.00
1985	210.00	150.00	185.00	62.48	57.00	50.00	50.00	60.00	135.00
1986	325.00	255.00	290.00	79.00	69.00	63.00	64.00	76.00	170.00
1987	330.00	270.00	300.00	96.74	82.00	79.00	78.00	90.00	220.00
1988	400.00	390.00	460.00	174.00	139.00	144.00	139.00	170.00	450.00