PN-AAT-865

A CONSULTANCY REPORT ON PULSES IMPROVEMENT IN NEPAL

BY

K. O. RACHIE, IADS CONSULTANT

AND

M. P. BHARATI, DOA AGRONOMY DIVISION

For The

Integrated Cereals Project
Department Of Agriculture
Ministry of Food and Agriculture
His Majesty's Government of Nepal

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FOREWORD

The Department of Agriculture/MOA/HMG/N, for the past 30 years, has been concerned in its field crop research programs with the improvement of the cereal crops (rice, maize and wheat) and more recently with the integration of these crops into cropping patterns with other crop species. During this time little effort has been directed towards research and genetic improvement of pulses. In recent years, however, the importance of pulses has been recognized and increasingly they are starting to receive some attention. This report is in response to a request from the Agronomy Division of the DOA to assess the present situation and potential of grain legumes in Nepal and to formulate a Coordinated Pulses Improvement Program.

The DOA and IADS were most fortunate in obtaining the consultant services of Dr. Kenneth O. Rachie who has an enviable reputation as a plant breeder/geneticist, administrator and program officer. Dr. Rachie has been ably assisted by Dr. M.P. Bharati, a pulse specialist with the DOA, who recently completed his Ph.D. from Iowa State University where he conducted research on soybean agronomy. Others who significantly contributed to the formulation of the pulses proposal are Mr. R.P. Sah and Mr. R.M. Chaudhary, legume specialists, of the DOA, who laid the foundation for the proposal more than a year ago and Mr. A.N. Bhattarai, Chief, Agronomy Division, who gave continuous guidance, stimulation and backstopping which resulted in the report becoming a reality.

It is sincerely hoped that this formulation (proposal) will stimulate interest and support for pulses improvement from HMG/N and donor agencies.

Carl N. Hittle
Project Supervisor
Integrated Cereals Project

ACRONYMS

1.	ADO	Agricultural Development Officer
2.	ADB	Asian Development Bank
3.	AIC	Agricultural Inputs Corporation
4.	AVRDC	Asian Vegetable Research and Development Center (Taiwan)
5.	CFRL	Central Food Research Laboratory
6.	CIAT	International Center for Tropical Agriculture (Colombia)
7.	CIMMYT	International Center for Maize and Wheat (Mexico)
8.	DDG	Deputy Director General of Agriculture
9.	DFAMS	Department of Food and Agricultural Marketing Services
10.	DG	Director General of Agriculture
11.	DLDAH	Department of Livestock Development and Animal Health
12.	DOA	Department of Agriculture
13.	FFT	Farmer's Field Trial
14.	FAO	Food and Agriculture Organization of the United Nations
15.	HMGN	His Majesty's Government of Nepal
16.	IAAS	Institute of Agriculture and Animal Science (Rampur)
17.	IARC	International Agriculture Research Center (ICRISAT, ICARDA, IITA, and others)
18.	IBPGR	International Board for Plant Genetic Resources (Rome)
19.	ICARDA	International Center for Agricultural Research in Dry Areas (Syria)
20.	ICP	Integrated Cereals Project
21.	ICRISAT	International Crops Research Institute for Semi-Arid Tropics (Hyderabad, India)
22.	IDRC	International Development Research Center of Canada
23.	IHDP	Integrated Hill Development Project (Nepal)
24.	IITA	International Institute of Tropical Agriculture (Nigeria)
25.	INTSOY	International Soybean Program (Illinois, USA)
26.	IRRI	International Rice Research Institute (Philippines)
27.	MOA	Ministry of Agriculture
28.	NifTAL	Center for Nitrogen Fixation (Hawaii, USA)

29. PWG Pulses Working Group (Nepal)
30. RCC Research Coordinating Committee
31. TU Tribhuvan University
32. T & V Training and Visit Extension Method
33. USAID United States Agency for International Development

PULSES GROWN IN NEPAL

English Name	Botanical Name	Local Name
Blackgram	*Vigna radiata* var. *mungo*	Mas, kalo dhal
Broadbean	*Vicia faba*	Keraiya Bakula
Chickpea	*Cicer arietinum*	Chana
Cowpea	*Vigna unguiculata*	Bodi
Fieldpea	*Pisum sativum* var. *arvense*	Kerau
Grasspea	*Lathyrus sativus*	Khesari
Horsegram	*Macrotyloma uniflorum* (Syn. *Dolichos biflorus*)	Gahat
Kidneybean (Phaseolus)	*Phaseolus vulgaris*	Simi
Lentils	*Lens culinaris*	Kusuro
Mungbean	*Vigna radiata* var. *aureus*	Mungi
Pigeonpea	*Cajanus cajan*	Arhar
Ricebean	*Vigna umbellata*	Mashyang
Soybean	*Glycine max*	Bhatmas

TERMS

Gazetted	Permanent Civil Servant, Officer Class (I-III)
JT/JTA	Junior Technician/Junior Technical Assistant (Non-gazetted but permanent)
Tarai	East-west strip of plains south of the foothills
Dhal	Soup or sauce made from dried, boiled pulses
Pulse	Dried legume seeds; syn: grain legumes, food legumes

A Consultancy Report on Pulses Improvement in Nepal

EXECUTIVE SUMMARY

Pulses are important crops in Nepal both in terms of their contribution to human nutrition and as components of indigenous cropping systems. In the aggregate they rank fourth in total area (224,00 ha in 1984/85), but fifth in production (94,000 tons) after rice, maize, wheat and finger millet. Current yields remain very low at 420 kg /ha and for both improved nutrition and quality of life there is an urgent need to increase total availability from 5.7 kg per caput to at least 12 - 14 kg /person/year. Any surplus above national food requirements can be readily exported to earn hard currency.

The constraints to increasing pulse production in Nepal are several and may be classed as institutional, socio-economic and technical. However, the most serious, immediate problem is lack of an adequately supported, nationally coordinated improvement program. Therefore, much of the subject matter of this report is concerned with establishing a national pulse program and discussing strategies and approaches to overcoming the several production constraints.

The highlights of these recommendations are briefly summarized below:

1. Coordinated Pulse Program. Establish a nationally coordinated pulse improvement program immediately (i.e. beginning 1985/86). Start up should be at Khumaltar (Kathmandu) for the first two years until the Sarlahi (Nawalpur) station is fully operational. The major goal of the program is to - "Increase and stabilize production and productivities of pulse crops

in Nepal." Specific objectives and scope are described in detail in the text of this report.

2. Staffing. Provide a team of scientists representing the major disciplines involved including agronomists (research and production), soil scientists, plant breeders, plant pathologists, entomologists, biochemists, engineers, socio-economists and extensionists. Total gazetted research staff required during Phase I (1985/90) is 26, and during Phase II (1990/2000) is 30; but they must be adequately supported by technical assistants, clerical staff and laborers; and all categories of permanent staff will total 56 during Phase I and 103 during Phase II.

3. Facilities. The Sarlahi station will require considerable improvement to bring it up to a functional level. First and foremost is basic station development like providing a water supply (for both irrigation and domestic use), electricity from the nearby power grid, and constructing buildings - both residences and office/laboratories. Other essential needs specific to pulses are mesh houses, field laboratories, field machinery, laboratory equipment, vehicular transport, office furnishings, and supplies.

4. Other Centers. Sarlahi should serve the needs of the Tarai and Inner Tarai; but the Hills and Valleys represent totally different agro-ecological conditions which may be best served from the center at Khumaltar. However, much work will need to be carried out at several secondary sites and sub-centers.

TARAI/INNER TARAI	HILLS AND VALLEYS
i) Kankai AF, Jhapa	i) Pakhribas AC, Dhankuta
ii) Hardinath AF, Janakpur	ii) Kavre AF, Kavre
iii) Parwanipur AS, Bara	iii) Lumle AC, Kaski
iv) Rampur AS, Chitwan	iv) Doti AF, Doti
v) Bhairawa AF, Rupandehi	v) Surkhet AF, Surkhet
vi) Nepalgunj, Banke	vi) Jumla AS, Jumla
vii) Tarhara AS, Sunsari	

5. Collaboration with FSP. Close collaboration with the Farming Systems Program will be essential to assure that research is relevant to farmer's conditions, contributes new innovations for pulses in the cropping system, and serves as a late stage evaluator of new technologies. The FSP will also broaden the scale of testing and verification through additional and complementary operational sites at 14 locations.

6. External linkages. The pulse program should start with the state-of-the-art technology from all sources. This will require avidly seeking and cultivating external linkages, especially with appropriate IARC's whose primary mission is to provide information and germplasm, and train young scientists from their client countries, like Nepal. However such collaboration should be directed to serve the best interests of Nepal, and not function simply as another testing site for the IARC's. Most relevant to pulse improvement in this country are ICRISAT, AVRDC, ICARDA, IITA, CIAT, INTSOY, NifTAL, IRRI (for cropping systems) and IBPGR (collecting). In addition, linkages should also be developed with national pulse programs in India, Pakistan, and Bangladesh on account of their similarity of growing conditions, crop species, and problems.

7. Pulse Working Group. The establishment of a special pulse working group is recommended to help review progress, discuss problems, and evaluate future work plans. This would be an advisory group, but it would also serve to encourage complementary work on pulses outside the purview of the program. Members should be nominated from all disciplinary divisions and cropping systems, as well as 'outside' organizations (Ad.hoc.) relevant to program objectives. Twice-yearly meetings are proposed to cater separately for the winter and summer legumes.

8. Multi-disciplinary approach. Pulses program personnel must work closely together as a team to maximize the impact of their collective efforts. Strong leadership will be necessary to function successfully in this way. As an aid to encouraging cross-disciplinary cooperation, for all conditions, the establishment of functional sub-groups along the following primary thrusts is advocated:

- Plant improvement to include plant breeders, agronomists, pathologists, entomologists, biochemists, soil scientists and others.

- Management: Agronomists, soil scientists, microbiologists, plant protectionists, breeders, biochemists, engineers, extensionists, and socio-economists.

- Plant protection: Pathologists, entomologists, agronomists, breeders, engineers, extensionists, socio-economists, and others.

- Product quality: Biochemists, socio-economists, engineers, extensionists, breeders, pathologists, entomologists and others (only in Phase II).

- Outreach/extension: Extensionists, socio-economists, agronomists, soil scientists, plant protectionists, breeders and others.

- Others: These may include socio-economists, mechanization and other areas.

Generally, representatives of the first or second listed discipline for each thrust could be named as convenor. The idea is for each sub-group to jointly plan and execute cross-commodity work activities for their thrust.

9. Coordination. The pulses, unlike most other commodity programs, will be highly complex and difficult to manage by virtue of the large number of species involved, different seasons of cultivation, and the diverse environments and locations under which grown. It may therefore be desirable to consider some decentralization toward the end of Phase I, and shift a portion of the burden and responsibilities of coordination to senior colleagues, to be named as 'Joint Coordinators' who would also be full time researchers. There are two natural divisions within the pulse group:

- Tarai Pulses: mainly winter legumes; also pigeon pea, mungbean, horsegram, cowpea.

- Hill Pulses: Summer legumes; especially soybeans, blackgram, cowpeas and others; also some winter legumes.

However, the pulse program should remain intact and under the leadership of a full-time coordinator for the forseeable future.

10. Travel. For the several reasons mentioned previously, the success of the Pulses Program will depend on the amount of travel done to carry out trials, observation tests, and other experiments. It will be particularly important for the Coordinator and his associates to travel frequently and for long periods. Since travel is frequently a hardship and always a strain, some means must be found to make it more attractive. Well maintained vehicles together with ample quantities of fuel must be provided; various types of public transport (including air travel) will be needed; and travel allowances must be increased. Therefore, central administration is requested to carefully consider this problem and its consequences on national development.

11. Species Focus: The most rapid progress will be made on those species already mandated to the IARC's (e.g. lentils, chickpea, pigeonpea, soybean, cowpea, mungbean, and Phaseolus bean). Therefore, initial focus should be given to lentils, chickpea, mungbean and soybean. Lentils will probably require the most intensive breeding effort. Another important summer species requiring special attention is blackgram on account of its importance in the hills and the fact that no IARC is responsible for this crop.

Grasspea, horsegram and fieldpea are significantly important in Nepal, but little prior work has been done on them. Moreover, grasspea can be toxic, causing lathyrism; and horsegram is comparatively high in metabolic inhibitors and the flatulence factor (though reputedly therapeutic for kidney stones). In order to determine their long term potential an agro-economic survey should be carried out in collaboration with IDRC which has a special interest in these two species. In addition, the

germplasm should be collected, assembled and evaluated, and any new trials on promising materials studied (as time permits). If grasspea and horsegram are not declining, but show signs of persisting, then improvement work on them may be expanded in Phase II.

Other species likely to increase rapidly in importance in Nepal are: pigeonpea, cowpea and Phaseolus beans. Therefore, they may merit increasing attention in collaboration with ICRISAT, IITA, and CIAT, respectively. For special situations (Kathmandu Valley) and higher elevations, broadbean, field pea, and certain phaseolus strains are appropriate and should receive attention as further information and experience dictate.

12. Breeding methodologies. Most of the initial breeding activities should be concentrated on evaluating, selecting, and testing genetic materials obtained through collecting within Nepal, and introductions from other countries and IARC's. Pulse scientists should collect landraces whenever possible; but assistance to carry out a systematic and comprehensive collection of indigenous germplasm should be solicited from the IBPGR. In seeking improved materials from external sources like IARC's large preliminary trials should be avoided in favor of few entry, advanced tests, and unreplicated, early generation nurseries.

Within a few years it will become necessary to commence recombining elite parental stocks for Nepalese conditions. However, it may prove more economic of time, effort and accuracy to have IARC's do the actual crossing and advancing the F_1's for Nepal. The most efficient selection system for self-pollinated legumes is some form of mass selection (to about the F_4) or single seed descent.

Nevertheless, a few of the most promising crosses should also be advanced in simple pedigree fashion to assure better control and greater chances of success.

Insofar as possible all segregating materials should be advanced two generations a year in suitable environments to speed the improvement process and obtain more widely adapted lines. Moreover, every effort should be made to select under simulated farmer's conditions - e.g. in relay or associated plantings, when necessary. This will require developing effective selection/screening methodologies.

13. Growth and management: A large backlog of management researdh is needed for the different legume species. Most of these studies, beginning with basic tillage and sowing and running to harvest must be repeated over time, under different agro-ecological conditions, for new or different cropping systems, and with all new strains and varieties proposed for release. Since irrigation is expanding rapidly, especially in the Tarai, it will be necessary to develop separate technology packages for both dryland and irrigated conditions. Since the work load will be very heavy, most of the research should be concentrated on a few species: e.g. lentils and chickpea in winter; and soybeans, blackgram/mungbean, pigeonpea , and cowpea in summer. However, studies should be expanded to include phaseolus bean, broadbeans and fieldpea as and when time permits and their potential so justifies. Other 'secondary' species may be added to the list during Phase II when further study and experience so warrant.

Some shift in emphasis is projected for Phase II when greater attention will be needed on conserving the resource base, increasing farmer operational efficiency

and recycling of plant nutrients. In particular, more recent developments in minimal tillage, use of modern general and selective herbicides, alley cropping, 'live-mulching', and multi-purpose green manuring need to be explored and possibly adapted for Nepalese conditions. Closely allied to these studies are investigations on the symbiotic nitrogen-fixing systems in the pulses. Major objectives in microbiology during both Phase I and II will be to search for more efficient Rhizobium strains for the several pulse crops and to find more efficient methods of delivering inoculum to the farmer.

14. Plant protection: By far the most effective and practical means of solving pest problems (diseases and insects) of crop plants is through host plant resistance. However, this process is by necessity, long term, and besides, satisfactory resistance may not be available nor effective for many important pests. Therefore, initial efforts may need to be focussed on pesticide use, escape mechanisms, and alleviating cultural practices. Concurrently, intensive efforts should be made to screen the germplasm and begin incorporating resistances into improved strains and varieties.

As plant protection develops further, a larger proportion of time and efforts would be concentrated on resistance breeding and developing integrated pest management schemes based on in-depth studies of pest life cycles, appropriate cultural practices, introduction and spread of natural parasites and predators of pests, and minimal use of less noxious chemical pesticides. Naturally, some survey and surveillance activities will be desirable, but these should be carried out generally for all crops, and would be secondary in importance for the Pulses Project.

15. Socio-economics: This is an important area still largely neglected for pulses. Studies are urgently needed to better characterize farmer motivations vis-a-vis pulses, evaluate new technology for relevance to local conditions and farmers needs, assess the impact of accepted technologies, and contribute to research planning on behalf of the farmer. An important initial project would be a comprehensive study of the present importance and potential of grasspea and horsegram as a basis for determining future improvement strategies on these crops. Such studies should also help elucidate the incidence of lathyrism and local concern for this disease in areas where grasspea is consumed regularly. In a similar vein the problems of nutritional qualities in horsegram may be assessed to determine whether genetic improvement for grain quality is a worthwhile goal in this crop.

Phase II activities would follow much the same lines as for Phase I. In addition, some major issues are likely to emerge such as the development of 'new' crops (e.g. cowpeas Phaseolus beans, and others), or 'revolutionary' management practices and cropping systems. The impact of these new technologies will need careful assessment both in economic and social terms before committing resources to do further work on and promote them.

16. Production and seeds: The pulse program should be vertically integrated in the sense that it is concerned about and participates in all aspects of research, extension, and production activities. Specifically, it should work closely with seed production agencies like the AIC in terms of supplying breeder's seeds, training technicians, trouble-shooting field problems and doing initial seed field inspections of newly released varieties.

On the production side, pulse researchers should be directly involved in the intensive Production Program, and particularly in the district-based cropping system schemes. They should be available to trouble shoot problem areas, help train specialists, provide protocols of practices, and even 'broker' seeds and inoculums if necessary to get the program moving.

17. Training: The first and fundamental base of any research program is trained, dedicated, and motivated staff. Training has both a building and replacement function and must be continued indefinitely, but the first 10 or 15 years are particularly critical. The Phase I and II targets for all levels of training are the following:

Category	Phase I		Phase II		15 - Years	
	No.	m/m	No.	m/m	No.	m/m
i) Post-graduate	11	300	19	586	30	886
ii) Group-training:						
Within Country	75	25	50	50	75	75
Outside Nepal	16	16	55	55	71	71
iii) IARC Courses	10	40	40	170	50	210
Total	112	381	164	861	226	1242

Estimated costs are included under the Budget Summary.

18. Other factors: Pulses research, regardless of how effective, cannot alone significantly raise production since several other factors are involved. Market demand, changing habits and attitudes, uncontrollable plant pest epidemics, increase in irrigation, availability of inputs (especially improved seeds, inoculums, pesticides) and other unforseen

events can all affect the areas planted and productivity levels. However, the public sector, through its planning, policy-making, and executing agencies, can help both increase and stabilize national production. The timely supply of inputs, availability of reasonable credit assuming stable price incentives, encouraging farmer cooperatives, and generally promoting pulse cultivation are all areas where government can influence production directly. The recent Intensive Production Program and District-Based Cropping Systems scheme appears to be an excellent vehicle for both educating growers and promoting improved production technologies. Pulse program researchers should therefore seek to participate fully with such programs.

FINANCIAL

Best estimates of costs for both Phase I and II show that major capital investments totalling Rs.200.4 lakhs will be needed during Phase I, and mainly during the first two years. This does not include basic station development estimated at Rs.23.7 lakhs for water, power, service buildings, irrigation, clearing and levelling required by both oilseeds and pulses at Sarlahi, as well as any other programs or activities carried out there. A brief summary of the proposed budget for Phase I and II is shown below:

Estimated Budget (Rs.'000)

	Category	Phase I*	Phase II**	Total	Percent
1.	Construction/equipment	20,037	1,800	21,837	28.5
2.	Expendable equipment/ supplies	1,080	2,700	3,780	4.9
3.	Operations/ Miscellaneous	1,550	3,350	4,900	6.0
4.	Training-all levels	4,820	15,990	20,830	27.0
5.	Salaries/allowances	4,936	20,866	25,802	33.6
	Total	32,423	44,706	77,149	100.0

*Five years (1985/1990) **Ten years (1990/2000).

THE IMPACT

The bottom line for HMG/N and donors is - what returns can be expected from a 15-year investment of about Rs.7.7 crores? A reasonable projection (see text) clearly shows that Nepal would benefit handsomely from increased pulse production. Although the impact during the start-up years, e.g. Phase I, is much lower than for Phase II, the total increase in production attributable to research during the first 5 years is conservatively estimated at 30,000 tons, worth Rs.24 crores at today's prices. Thus, the first five years costs amount to only 13.5 percent of the projected increase. Phase II production rises are expected to be much more rapid when the research program becomes fully operational. Increases attributable to improved technology above current productivity levels are estimated at 635,300 tons worth Rs.503 crores for the 15 years 1985/2000. Thus, the entire cost of the program in Phases I and II would amount to only 1.5 percent of the value of increased production during that period.

Of perhaps even greater significance would be the impact on improved human nutrition and the quality of life as present availability of pulses totalling 5.7 kg per caput would rise to 9.2 kg /person/year, an increase of 61 percent. However, if the land area (viz. cropping intensity) devoted to pulses also increased at an estimated 2.0 percent per year (over 14 years), total availability of pulses by the end of the century would reach 12.2 kg per caput (assuming a population of 23.5 million and annual production of 287,600 tons) and would therefore contribute a more ideal 8.4 g of protein (21% of requirements) to the daily diet.

/1

A CONSULTANCY REPORT
ON
PULSES IMPROVEMENT IN NEPAL

I. BACKGROUND

The grain legumes or pulses not including groundnuts (considered an oilseed) are important as foods, feedstuffs and as key components of cropping systems in Nepal. Collectively, they rank fourth in area (224,000 ha in 1984/85) after rice, maize and wheat, but yields remain disappointingly low at only 420 kg of grain per hectare. Total availability is only 5.7 kg per person/year, a consumption level that should be at least doubled. This is attributable primarily to the low priority they receive both in terms of improvement and in farmers' production systems. However, the vital role of these crops in human and animal nutrition, soil improvement, and for export, amply justify mounting a major effort on research and development coinciding with the 7th Five Year Plan. It is proposed that this be done as a "coordinated Pulse Improvement Program" (or "pulse program"). The timing is particularly appropriate as good progress has already been made in similar programs on rice, maize and wheat. To be effective and successful such a program must command the full support of HMG/N and external donor agencies. It will also require an outward looking approach to maximise the exploitation of useful technology generated elsewhere, especially at the International Agricultural Research Centers (IARC's) and neighboring countries. The program will also feature a strong training component to ensure that young Nepalese researchers have the necessary capabilities to effectively carry out the enormous and complex task ahead.

THE AGRICULTURE

The total area of the country is 141,000 km^2 and about 3.13 million hectares, or 22 percent of the land area, are cultivated. Agriculture is the dominant sector of the Nepalese economy, produces about 60 percent of the GDP, employs over 90 percent of the population (now stands at 16.6 million: 2.7 percent annual growth rate), and accounts for about 15 percent of the total exports. Traditional, subsitence level agriculture dominates the sector as small holdings. The average farm size is less than 1.25 ha in the hills and 2.11 ha in the Tarai. Per capita income for the country is only US $130.

The Environment

Agriculture in Nepal is particularly complex owing to the diversity of crop growing environments in the country. Within its north south width of 130 to 240 km between the latitudes of 26°20' and 30°30' N and longitudes of 80°05' to 26°15' E can be found a wide range of climate and topography from the torrid and humid sub-tropical lowlands to the alpine elevations above 4000 m. Thus, agriculture can be zonalized into three major categories: (1) the plains comprising the Tarai and Inner Tarai (around 100 to 300 m elevation), (2) mid hills and valleys (500 to 2000 m) and the high hills and mountains (above 2000 m). The average annual precipitation is 1600 mm. with 80 percent occuring during the monsoon (July - September), but ranges from about 1000 mm. to more than 5000 mm depending on location and topography. The moisture gradient increases from West to East. The soils are also highly variable being derived mainly from young parent materials of the Himalayan massif.

The Farmer's Challenge

Despite man's best efforts he remains partly at the mercy of his environment, and particularly in the growing of crops. However, long experience coupled with careful study of the soils, climate and weather patterns allow a probability estimate of growing conditions from year to year. Farmers understand this principle, but they must be inherently conservative as their very survival may depend on at least partial success in realising a harvest. Security at the subsistence level is frequently achieved by growing several different crops as well as variants within each species in the farming system. At the small holder level it is usually economic of the farmer's efforts and inputs to combine two or more crops on the same land on the assumption that something will be harvestable despite most adversities.

In monsoon climate like that of Nepal moisture is the key to successful crop production and particularly during the winter. Often, moisture is precarious from about November to April where irrigation is not available. The approach to this problem is through adopting appropriate management practices to conserve moisture and developing varieties tolerant of drought. The latter involves both 'escape' - usually through earliness - and plant tolerance of moisture stress. Tolerance is often dependent on a vigorous, proliferating root system, ability to go dormant during unfavorable periods, and specific physiologic mechanisms like stomatal closure and cuticular waxy layers. In the case of pulses, moisture stress will be more important in the winter legumes. The opposite problem, water logging, can also occur particularly in low lying areas in summer.

Soil and plant nutrients pose other problems. Fortunately, most Nepalese soils are comparatively fertile and do not have the added complications of pH extremes. However, many soils

in outwash and delta areas are coarse textured and naturally droughty; while other areas, especially lowlands, are high in clay and subject to waterlogging. Both situations pose problems for legumes in terms of limitations on species (and variation within species) and special management practices required. Generally, the winter legumes, especially grasspea, lentils, and chickpea are more or less resistant to drought. Among the summer species, by far the most drought resistant crop is pigeonpea by virtue of its excellent root system. Other legumes noted for this attribute include cowpea and horsegram among the major species in Nepal. On the other hand, relatively few grain legumes tolerate water logging, but perhaps the best are soybean, ricebean and some variants of cowpea. The rapid expansion of irrigation in the Tarai offers new opportunities for pulses, especially short duration species (e.g. cowpea, mungbean) which can fit between the major cereals or can be grown as intercrops and relays with cereals and oilseeds.

PROSPECTS FOR PULSE IMPROVEMENT

The highly diverse environment allows cultivating a wide array of plant species. At least a dozen pulses occur in various situations and in different parts of the country, although five species - grasspea, lentils, chickpea, horsegram and soybeans - occupy 78 and 79 percent of the land and production of pulses respectively. Nevertheless, several other currently less important species are likely to have much greater potential than currently indicated by production statistics. While the large number of different pulse species available is a distinct advantage in production, they pose several difficulties in planning and evaluating a nationally integrated pulse program. Obviously, it is not possible to mount full scale improvement efforts on each of the 9 to 12 crops involved. Priorities need

to be established and strategies mapped out designed to achieve the greatest impact with finite resources in the shortest possible time frame. A further complicating factor is that the legume species do not represent a single organism, but rather, a synergistic system involving the interaction between the plant and its respective nitrogen fixing Rhizobium species. That is, the legume researcher must ensure both organisms are functioning optimally for both experiments and general production to be successful.

II. IMPORTANCE, UTILIZATION AND DESCRIPTION

Virtually all farmers in Nepal grow one or more species of grain legumes depending on crop adaptation and farm needs. In the hills and mountains legumes are grown mainly for home consumption, while in the Terai they are grown for the market either for processing and resale to local consumers or for export, principally to India. The bulk of production in the Terai and Inner Terai is from the winter pulses, mainly grasspea, lentils and chickpea. In the hills the summer legumes, especially soybean, blackgram and horsegram dominate legume cultivation; while in the higher, sub-mountainous region peas and Phaseolus beans are the two most important summer legumes.

PRODUCTION

The combined production of all pulses including soybeans in Nepal was 213,000 ha and 64,200 metric tons in 1983 representing the fourth largest production crop in terms of area after rice (1.3 M ha) corn (0.47 M ha), and wheat (0.4 M but ranking fifth in production being also exceeded by millet with less area sown but higher productivity (0.12 M ha and 122,000 tons of grain.). The production of the major grain legume crops in 1983 is shown in Table 1.

Table 1. PRODUCTION OF MAJOR GRAIN LEGUMES IN NEPAL IN 1983 (FROM UNPUBLISHED DATA OF THE DEPARTMENT OF FOOD AND AGRICULTURAL MARKETING SERVICES (DFAMS/N, 1983)

Rank	Crop	Area ('000 ha)	Area Percent	Production ('000 ha)	Production Percent	Yield kg/ha
1.	Grasspea	49.2	23.1	18.7	22.2	380
2.	Lentils	44.5	20.9	17.0	20.2	382
3.	Chickpea	34.3	16.1	13.1	15.6	381
4.	Soybean	18.4	8.6	10.1	12.0	548
5.	Horsegram	20.7	9.7	7.9	9.4	381
6.	Mungbean*	16.0	7.5	6.1	7.2	381
7.	Pigeonpea	12.7	6.0	4.8	5.7	377
8.	Fieldpea	11.2	5.3	4.3	5.1	383
9.	Others**	6.0	2.8	2.3	2.6	366
		213.0	100.0	84.2	100.0	395

* Includes blackgram

**Presumed to include cowpea, broadbean, and phaseolus

The major producing areas for grain legumes in Nepal include the Tarai, Inner Tarai and the Hills and Valleys up to about 2000 m elevation.

Production is concentrated in the following districts (after Bharati, 1985):

TARAI		HILLS AND VALLEYS	
Sarlahi	Nawalparasi	Makawanpur	Dhading
Dhanusha	Rupandehi	Kathmandu	Gorkha
Mahottari	Kapilvastu	Lalitpur	Kaski
Siraha	Banke	Bhaktapur	Terahthum
Rautahat	Bardia	Kabhre	Tanahu
Bara	Kailali	Sindhupalchowk	Palpa
Parsa	Kanchanpur	Nuwakot	

Recent production of the pulses and their distribution in Nepal are also shown in tabular form in Appendix 1 and in maps in Appendix 2.

UTILIZATION

The pulses are important in several respects, but especially as a key ingredient in human diets heavily skewed toward carbohydrates from cereals and starchy crops with limited animal products. Other important uses are as protein concentrates and fodder for animals, as important components in cropping systems, and for soil improvement mainly on account of their ability to fix atmospheric nitrogen. Moreover, it appears there is good potential for some pulses to be grown as cash crops for export. Among the different crops, the most promising exports are lentils to the Middle East and chickpeas and pigeonpeas to India. It is estimated that 8,100 tons of pulses with an approximate value of Rs.9.0 crores were exported during 1981/82. This amount may be considerably under estimated since there is free movement between India and the Nepali Tarai, a surplus pulse producing region.

Grain Legumes for Food

Grain legumes can be used in many forms for human food. The tender green leaves, pods and seeds of several species are used as vegetables; whereas the mature, dried seeds (pulse) may be cooked whole or ground into flour for making noodles and several fried or baked preparations. While all the important legumes grown in Nepal are used as a pulse, the green seeds and pods of several species make excellent vegetables, especially: pigeonpea, cowpea, field pea, broad bean, chickpea, and Phaseolus beans. However, the cowpea is unique in being highly edible in four forms: tender green leaves, green pods, green seeds, and as a pulse.

The Pulse form of grain legumes is particularly important in vegetarian and starchy diets as a highly relished protein concentrate (averaging about 25 percent of protein on a dry weight basis) also providing other essential nutrients. The amino acid profile of pulses is complementary to that of cereals, and they are valuable sources of other nutrients like the 'B' vitamins, calcium, phosphorus and iron. A frequently overlooked bonus is their food energy which is equivalent to that of cereals on a dry weight basis (330 to 350 k cal/100 g). However, several pulses - notably Phaseolus beans and soybeans-contain high amounts of stachyose and other long chain sugars responsible for flatulence, and certain metabolic antagonists like the trypsin inhibitor. Nevertheless, it is possible to eliminate a portion of these undesirable components through cooking, and sometimes by breeding if variability occurs and it can be readily screened for.

Pulses for Animals

The aftermath from pulse harvest is a valued fodder as it often runs higher in protein than cereal straw, especially if the leaves are retained and the foliage remains green at harvest. Sometimes pulses are planted as a 'protein bank' to be grazed in the green stage before ripening; or pulse fields may be diverted for livestock feed if lack of moisture or other hazards prevent normal seed formation.

Several pulses (as grain) are also used for high quality feed concentrates for animals like poultry requiring high protein levels for efficient egg and meat production. Pulses are also fed in combination with other grains and concentrates to ruminants during periods of heavy stress, such as bullocks under peak work loads and lactating, very young or sick animals.

Pulses in the Cropping System

The Pulses are predominantly grown as associated and relay crops with cereals and oilseeds. The summer species are mixed with maize and finger millet in the hills; but some crops like blackgram, soybean, pigeonpea, horsegram, and ricebean are also grown on paddy bunds in low-lying (khet) areas. Winter legumes, especially grasspea, lentils and chickpea, are often intermixed with winter crops like wheat, barley, mustard and linseed in the Tarai; but sometimes they are sown as relay crops with late rice when winter moisture is limiting. In other cropping patterns short duration mungbean and cowpea are increasingly planted as 'catchcrops' between wheat and rice in irrigated areas of the Tarai.

Dominant cropping patterns are illustrated in Appendix 3, the most typical of which are*:

Tarai:
- (i) rice - grasspea + lentil + mustard + linseed
- (ii) rice - chickpea + lentil + mustard + linseed
- (iii) maize - chickpea + grasspea + lentil + mustard
- (iv) rice - rice - mungbean
- (v) rice - wheat - mungbean
- (vi) pigeonpea - fallow
- (vii) rice + pigeonpea (on bunds)

Hills/Valleys: (i) maize + soybeans - mustard

(ii) maize + cowpea - mustard

(iii) maize / blackgram - mustard

(iv) rice + soybeans (on bunds)

* Symbols denote system: (-)= sequence; (+) = association or intercropping; and (/) = relay cropping.

Marketing

Most of the pulses produced in the hills are consumed at home, whereas in the Terai a considerable portion of the production is sold by farmers usually in their own village. This results in a complex marketing system. The normal channel is for farmers to sell their produce to a village merchant or to collecting agents. The latter may then sell the pulse (mainly pigeonpea and lentils) to processors for cleaning, husking, and splitting, or to wholesalers. Processors may sell the split pulse directly to consumers or to wholesalers, or to the latter through a commission agent. Wholesalers may store the pulse for later distribution when prices rise or export them to India and abroad (see marketing flow in Appendix 4). The end result is that farmers are often forced to sell during periods of declining prices (at harvest); while consumers (including former producers) pay premium prices throughout the year. The average spread between the producers price and consumer's cost often approaches 100 percent.

DESCRIPTION

There are at least a dozen grain legume species grown in Nepal. Of these, eight species occur in significant amount making up 97.2 and 97.4 percent of the area and grain production, respectively. Nevertheless, several secondary pulses may have been overlooked in determining production, or demonstrate considerable potential for the future. Therefore, to better understand the role of the different species and to provide a basis for the strategies for improvement to follow, a brief description of the several important and potentially useful legume species is given in Appendix 5. Further information on their ecosystematic and generalized performance attributes are tabulated in Appendices 6 and 7 (adopted from Duke, 1978). However, the most important information needed by planners and researchers in developing legume improvement strategies are cropping patterns and major biotic constraints in Nepal as shown in text Table 2.

Table 2: CROPPING PATTERNS AND MAJOR BIOTIC CONSTRAINTS OF GRAIN LEGUMES IN NEPAL

CROP	SEASON	REGION*	ROLE IN CROPPING SYSTEM	MAJOR INSECTS	PESTS DISEASES
Lentils (*Lens culinaris*)	Winter	H V T+IT	Sequence crop after maize Relay crop with rice or sequence crop after maize Relay crop with late rice or sequence crop after rice or maize	Cutworm Pod borer Aphids	Wilt Root rot Rust
Chickpea (*Cicer arietinum*)	Winter	H V T+IT	Sequence crop after maize Relay crop with rice or after maize Relay crop with late rice or sequence crop after rice or maize	Cutworm Pod borer Aphids	Wilt, Root rot Botrytis, Rust Stunt virus Other viruses
Grasspea (*Lathyrus sativus*)		H+V T+IT	Sequence or relay crop after maize or rice " "	Few serious insect pests	Diseases not serious nor adequately studied.
Fieldpea (*Pisum sativus*)	Winter	H+V	Association crop with winter cereals; or as a monocrop.	Aphids Cutworm Pod borers	Wilt Leaf spots Viruses
Soybean (*Glycine max*)	Summer	H V T+IT	Intercrop with maize Intercrop with maize or on rice bunds Monocrop in maize growing areas	Hairy Caterpillar, Chinch bug, Stem borer Leaf miner Leaf folder Gray weevil	Progeye leaf spot, Pod and stem blight, Cercosporella in hills, Rusts
Mungbean/ Blackgram (*Vigna radiata*)/ (*Vigna mungo*)	Summer	H V T+IT	Intercrop or relay with maize Intercrop with maize, blackgram also grown on paddy bunds. Catch crop after winter crops like wheat; and before or after rice (blackgram)	Hairy caterpillar, Pod borer, Thrips Aphids Beetles	Yellow mosaic virus, Pod and leaf blight, Progeye leaf spot, Bacterial leaf spot Powdery mildew
Horsegram (*Macrotyloma uniflorum*)	Summer	V+T+IT	Usually grown as monoculture, but may be mixed with oilseeds, millet or other pulses.	Hairy caterpillar Pod borers Leaf caterpillar	Root rot and dieback Rust Anthracnose Bacterial leaf spot
Pigeonpea (*Cajanus cajan*)	Summer and Winter	T+IT V	Monocrop in upland areas, and on paddy bunds Intercrop with maize harvested following spring	Heliothis pod borer, other Lepidopterus species	Pigeonpea wilt Sterility mosaic virus Powdery mildew
Cowpea (*Vigna unguiculata*)	Summer	H T+IT	Intercrop or relay crop with maize Catch crop before or after rice	Aphids Thrips Pod borers Hairy caterpillar	Pod and leaf blight Anthracnose

* H = Hills; V = Valleys; T = Tarai; IT = Inner Tarai.

III. CONSTRAINTS AND STATUS OF IMPROVEMENT

CONSTRAINTS

There are numerous constraints to increasing the production and productivities of grain legumes in Nepal. These may be classed as indirect (institutional and socio-economic) and direct (the environment, biotic factors and management). These are further discussed in the sections to follow.

Indirect Constraints

Most indirect constraints are the result of official policies or lack thereof. Other deterrents are attributable to the producer and include ignorance about the potential and optimal management practices for grain legumes, lack of credit during key periods and generally inadequate planning.

A. Support for research. The most immediate and important problem at present is lack of support for grain legume improvement in Nepal. Only one half-time agronomist and two Assistant Agronomists are directing the national research program with the collaboration of half time contributions of research officers from the Divisions of Entomology, Plant Pathology and Soil Science (3 x 50% time). Only five non-gazetted staff members assist the agronomists at Khumaltar and Parwanipur. Operational funds are minimal and facilities are virtually non-existent. For example, the budget available for Fiscal Year 1984/85 was only Rs.170,000 (i.e. $10,000).

B. Extension/Production. As a consequence of lack of support for research there is relatively little improved technology to extend. Moreover, seeds of the few improved legume strains are often not available or in short supply. Then,

as with other crops, inputs like pesticides and fertilizers may not be available on time or are unaffordable to the farmers. Perhaps most important for growers would be nationally organized grain legume promotion campaigns. However, this would also require special training courses for extensionists and production specialists.

C. Credit and inputs. The pulses are generally less costly to produce than other crops as a consequence of their lower requirements for fertilizers. Nevertheless, some plant nutrients like phosphorus and minor elements may be essential and return handsome dividends to the farmer under certain conditions. However, the most important inputs are likely to be good quality seeds together with the appropriate Rhizobial inoculum (if a new crop), and pesticides at critical stages of growth, especially during flowering and pod formation. Sometimes only 1 to 3 pesticide applications can increase yields 2 to 3 times.

D. The grower. Farmers, like everyone else, have their own specific problems and hangups. Mainly, these stem from ignorance and lack of experience; but sometimes poor planning and inadequate management are involved. As a consequence of general lack of good technology and low yields, grain legumes are often planted on marginal lands with minimal inputs and management. Even the most important operation like weeding at critical periods is neglected. Another problem may be operational conflicts with other crops and inadequate storage facilities resulting in late harvest and spoilage losses. These may also oblige the farmer to sell his pulses at harvest when prices are cyclically depressed.

Direct Constraints

Direct constraints are considered to be those imposed by the environment, both physical (climate, weather, soils and topography),biotic (insects, diseases, nematodes, non-disease microbes, and animals) and management. These are briefly discussed below:

A. Physical constraints:

1. Climate/weather.In Nepal much of the influence of climate is related to elevation and partially to topography and region. However, there is an important seasonal effect as winters are normally cool and dry, while summers (monsoon) are humid and range from hot to alpine. Generally, rainfall increases from West to East, but topography is also important causing much higher or lower total precipitation in specific locations. Extremes range from about 1100 to 5000 + mm; but the 'Norm' is usually 1400 to 2000 mm. In some areas and seasons hailstorms occur and are devastating to crops during the late vegetative to mature growth stages.

2. Soils and topography. Soils of the hills and upland regions are largely derived from young parent materials and classed as inceptisols or alfisols; while the valleys and the Tarai are mainly sedimentary - sandy or clayey loams. Except where highly leached, eroded or heavily cropped without nutrient replenishment, the soils are productive and range from about pH 5 to 6.sloping lands are more fragile than level areas and require much greater care in use and management. Major soil-related constraints are drouthiness or coarse texture, extremes of pH, and specific plant nutrient deficiences, like P, K, Ca or M.O.

B. Biotic constraints: The most important biotic constraints to legume production are plant diseases (including nematodes) and insect pests. While several pests or related races may be common to two or more pulses, they may differ in virulence and importance depending on species, location, season, and other factors. This relationship is partially shown in Table 3.

C. Management constraints: The grower must assume a fair share of the responsibility for low pulse yields and production. Too often, legumes are used as catch crops that receive very little attention except for rapid scattering of seeds. Little attention is paid to optimizing cultural practices or plant protection of any kind. Often the farmer is ignorant about improved varieties and does not understand the need for Rhizobium on new lands. In some cases the harvest, threshing, and storage of pulses compete with the same operations on other crops - especially the major cereals or oilseeds. Under these circumstances legumes usually come off in second place.

Table 3: MAJOR DISEASES AND INSECT PESTS OF GRAIN LEGUMES IN NEPAL (after Bharati,1985)

Legend:

* = Lesser importance; ** = important
*** = Crop Threatening.

PEST	CROP						
	Soy-bean	Mung-bean	Black-gram	Cow-pea	Pegeon-pea	Len-tils	Chick-pea
Diseases:							
1. Cercospora 1/	***	***	***				
2. Pod/Stem blight	**						
3. Pod/leaf blight		***	***	***			
4. Anthracnose				***			
5. Powdery mildew		*	*		*		
6. Rust	***					*	*
7. Cercosporella 2/	*						
8. Botrytis							***
9. Wilt					**	***	***
10. Root Rots						**	*
11. Bacterial L.S.		*	*				
12. Sterility mosaic					***		
13. Stunt virus							*
14. Yellow mosaic		**	**				
15. Other viruses							*
Insects:							
1. Hairy caterpillar	***	***	***	***			
2. Pod borers 3/		*	*	*	***	*	***
3. Stem borers	*						
4. Chinch bug	*						
5. Leaf miner	**						
6. Leaf folder	**						
7. Gray weevil	*						
8. Beetles, various			*				
9. Thrips		**	**	**			
10. Aphids		**	**	**		**	*
11. Cut worms						***	**
12. Other Lepidopters					**		

1/ Frogeye leafspots. 3/ Heliothis Sp. and others

2/ Mainly in the hills.

The Dilemma

The consequences of these several constraints and inadequate support for research and development have led to the following situation:

1. Dearth of high yielding, widely adapted, disease and pest resistant varieties for the different agro-ecological conditions and farmer needs (including intercropping) in the country.

2. Limited information on optimal management practices for different situations, including: tillage practices, time of sowing, plant densities, nutrient and water requirements, weed control, seed treatment, Rhizobial inoculation, harvesting and threshing, and seed processing and handling.

3. Inadequate or suboptimal plant protection measures to most economically manage plant pests and diseases with minimal hazards to humans, animals and the environment.

4. Lack of knowledgeable and trained extensionists, seed producers, and production specialists to promote grain legumes and expedite the transfer of technology to both producers and processors.

This adds up to virtually complete lack of commodity infrastructure needed to increase and sustain grain legume production. Therefore, considerable efforts, enthusiastic support and promotion will be required over several years to reach the level of development attained by the major cereals in this country.

THE STATE OF PULSE IMPROVEMENT

Research in Nepal:

Despite the several major constraints, operational problems, and lack of staff, some important advances have been made on pulse improvement in Nepal. These have been achieved by a small cadre of highly dedicated researchers working mainly at Khumaltar and Parwanipur using as testing sites experimental farms at Kankai, Hardinath, Jhumka, Bhairahwa and Nepalgunj in the Tarai; and Pakhribas, Kabhre, Jumla, Lumle and Kakani in the Hills. Wisely, the grain legume group has been soliciting help and technology (including germplasm) from IARC's, especially AVRDC, ICARDA, ICRISAT, IITA, INTSOY, and IRRI. Concurrently some local collecting was done, trials were organized, and agronomic experiments were carried out.

Varietal improvement As a consequence of extensive testing both on agricultural stations/farms and in farmers' fields the following varietal recommendations were made:

CROP	VARIETY	YEAR
- Mungbean	Pusa Baisakhi	1976
- Soybean	Hardee and Hill,	1976
- Lentils	Sindoor, Shishir, and Simrik	1979
- Chickpea	Dhanush and Trishul	1979
- Blackgram	Kalu	1980

Cropping systems and agronomy. Concurrent with variatal improvement, critical studies have been carried out on legumes in cropping systems, and or cultural practices, like sowing times, plant populations, and fertilizer recommendations. These have provided a limited number of technological packages for the new varieties and are beginning to evoke considerable interest by farmers and development agencies, including seed production organizations, hill agriculture, and extension. In addition, some good progress has been made on Rhizobium inoculation and in identifying more effective strains of these symbionts, especially for soybean, lentils, chickpea, and broadbean. Commercial use of improved inoculants has been particularly effective on soybeans and lentils in the Tarai and at some hill stations. Some distribution of selected inoculums has been done on a limited scale by the Soil Science Division at Khumaltar.

Among recent developments of considerable potential significance to rice farmers is the planting of lentils as a relay crop in late-sown (July/August) rice. The lentils can be broadcast into the maturing rice crop up to about a month prior to harvest. If moisture conditions are reasonably favorable the lentils will produce as much as 8 - 10 q/ha or more grain with virtually no input, except the seed, a casual weeding and harvest.

Another promising development is the combination of mustard and chickpea which is clearly superior to either crop in monoculture or most other combinations. Amongst the summer legumes, cowpea shows considerable potential as an alternative to soybean in combination with maize. Another good combination with late maize in drier areas is long duration pigeonpeas in the Tarai. The pigeonpea comes on after the maize is harvested

and matures in late March or April. Ofcourse pigeonpea, like the winter legumes, also has good potential for export to India.

Pests. Investigations on legume pests have focussed on identification of the major diseases and insect pests of specific crops. Studies on Cercospora of soybean indicates that a new race may occur in the Kathmandu Valley. It has also been possible to do some screening for host plant resistance and some promising lines have been identified. In entomology the hairy caterpillar has been identified as a major pest of legumes in summer and effective control measures have been developed.

Departmental recommendations. Based on field trials and other information some general recommendations for growers have been formulated by the DOA. These are summarized in text Table 4.

Table 4: SOME RECOMMENDATIONS ON PRODUCTION PRACTICES FOR MAJOR LEGUME SPECIES IN NEPAL

Crop	Season Region[1/]	Cropping System	Sowing Time	Sowing Rate	Plant Nutrition N - P - K	Plant Nutrition Inoculum[2/]	Pest Control[3-4/]
Lentils	W IT & T H & V	Rice-lentil (sole or relay) Rice/maize-lentil (sole or relay)	Late Oct. Early Nov.	40 Kg/ha	20-40-20	+ +	5% Aldrin/BHC dust @ 15-20 Kg/ha for soil borne insects. Thiodan 2 ml/liter of water for foliar insects.
Chickpea	W IT & T	Rice-chickpea (Rainfed)	Late Oct. Early Nov.	60 Kg/ha	20-40-20	+	Same as Lentil
Fieldpea	W IT & T H & V	Intercrop with winter cereals				+ +	Metasystox (2-4 ml/l water) for sucking insects.
Soybean	S H & V IT & T	Intercrop w/maize and paddy bunds Monocrop-soybean	May May-June	60 Kg/ha	40-60-40	+ +	Thiodan (2ml/l) for foliar insects. Hand picking of hairy caterpillar 1st, 2nd, 3rd, instar larvae.
Blackgram	S H & V IT & T	Intercrop with maize, paddy bunds catchcrop during spring & fall.	May July March Oct.	30 Kg/ha	20-30-20	. +	Thiodan (2ml/l) for foliar insects.
Mungbean	S IT & T	Rice-wheat-mung (irrigated)	March & Oct.	25 Kg/ha	20-30-20	+	Same as blackgram.
Pigeonpea	S IT & T	Paddy lands Rainfed highlands	July	15-25 Kg/ha		+	Same as blackgram.

1/ W = Winter; S = Summer; IT & T = Inner Tarai and the Tarai; H & V = Hills and Valleys.

2/ + = Inoculum is needed.

3/ Thiodan spray should be stopped one month before harvest.

4/ Cercospora leaf spots in soybean and other species may be controlled by foliar sprays of Difolitan or Diathane M-45 at 15 day intervals. Seed borne pathogens like anthracrose, purple stain, phomopsis can be controlled by seed treatment with Thiram (2g/kg).

Research Outside Nepal

An important consideration in planning research and development of the different grain legume species is the magnitude of interest and effort underway in other countries and in the international community. Those crops enjoying attention by international agencies and other countries are likely to improve rapidly; whereas the species of little interest abroad may not have the potential nor backup support to advance on a sustained basis. Therefore, limited resources may be better diverted toward alternative species with both immediate and long term potential.

Among the group of legumes described in the previous section, the following international agencies and countries have significant improvement efforts underway.

1. Lentils. ICARDA, USA (Washington), India, and others.
2. Chickpea. ICRISAT, ICARDA, India, USA (California), Mexico, and some Andean countries.
3. Broadbean: ICARDA, Britain, Canada, Ethiopia, some Andean countries.
4. Fieldpea. ICARDA(as forage), Canada, Scandinania , Britain, some Andean countries.
5. Soybean. AVRDC (for the sub tropics), IITA (for the low latitude tropics), INTSOY (general); also USA, Canada, Mexico, Colombia, Brazil, Australia, several others.
6. Mungbean. AVRDC, Philippines, Indonesia, India, Thailand, China.
7. Pigeonpea. ICRISAT, India, Kenya, Australia, Caribbean region.

8. Cowpea. IITA, IRRI (CS), India, Nigeria, Senegal, Tanzania, Philippines, Brazil, USA (Florida, Mississipi, Texas).

9. Fieldbean (Phaseolus sp.). CIAT, Central and South America, USA (several states), Britain, Europe, East Africa.

10. Secondary species. Lima bean: germplasm and minimal studies underway at CIAT, also in the USA (vegetable); Cluster bean: India and USA; Rice bean: Australia and S.E. Asia; Adzuki bean: Japan; Hyacinth bean: Brazil, India.

Among the other major and secondary species there does not appear to be any significant national or international improvement activities on grasspea (Lathyrus sp.) nor on horsegram (Macrotyloma sp.) except to a limited extent in India and Bangladesh. Since these two species remain rather primitive and there is virtually no backlog of technology available, any progress in improvement is likely to be slow despite a substantial investment of resources and efforts.

IV. INSTITUTIONAL DEVELOPMENT

The improvement of pulses will require establishing a nationally Coordinated Pulse Improvement Program (CPIP), defining the program's goals and objectives, outlining strategies, preparing a plan of work, and following these assiduously. By relating goals and objectives to institutional and production constraints it is possible to structure a functioning improvement program, and to outline the strategies by which a plan of operation may be formulated. However, the primary key to success will be capable leadership, especially in the coordination post. It will be necessary to build the pulse program virtually from the ground up. Staff will need to be recruited and trained, multi-disciplinary research activities organized, and operations directed to achieve the program's goals as efficiently as possible. It will also be necessary to deal not only with several MAG/N agencies, but also with at least two donors, representatives of several IARC's, and pulse scientists from other countries.

INSTITUTIONAL FRAMEWORK AND LINKAGES

The Coordinated Pulses Improvement Program is one of nine national commodity improvement and development programs. It is responsible to the Ministry of Agriculture through the National Agriculture Research Center under the Department of Agriculture. This relationship, as proposed by Pradhanang (1984) is shown in Figure 1.

Organizational Structure:

The new pulses program will function independently, but will promote close linkages with the seven disciplinary divisions headquartered at Khumaltar: Agronomy, Plant Pathology, Entomology, Agriculture Botany, Soil Science, Agriculture Engineering and Agriculture Extension/Socio-Economics. Its supporting services will include Administration, Accounts, Stores, and Revenues. The Primary functions of the program will be Research, Outreach, Production, and Training/Information. Each of the functions will include several activities as shown by Bharati (1985) in Figure 2.

Figure 1: Suggested Crop Research Organization Chart (Pradhanang, 1984)

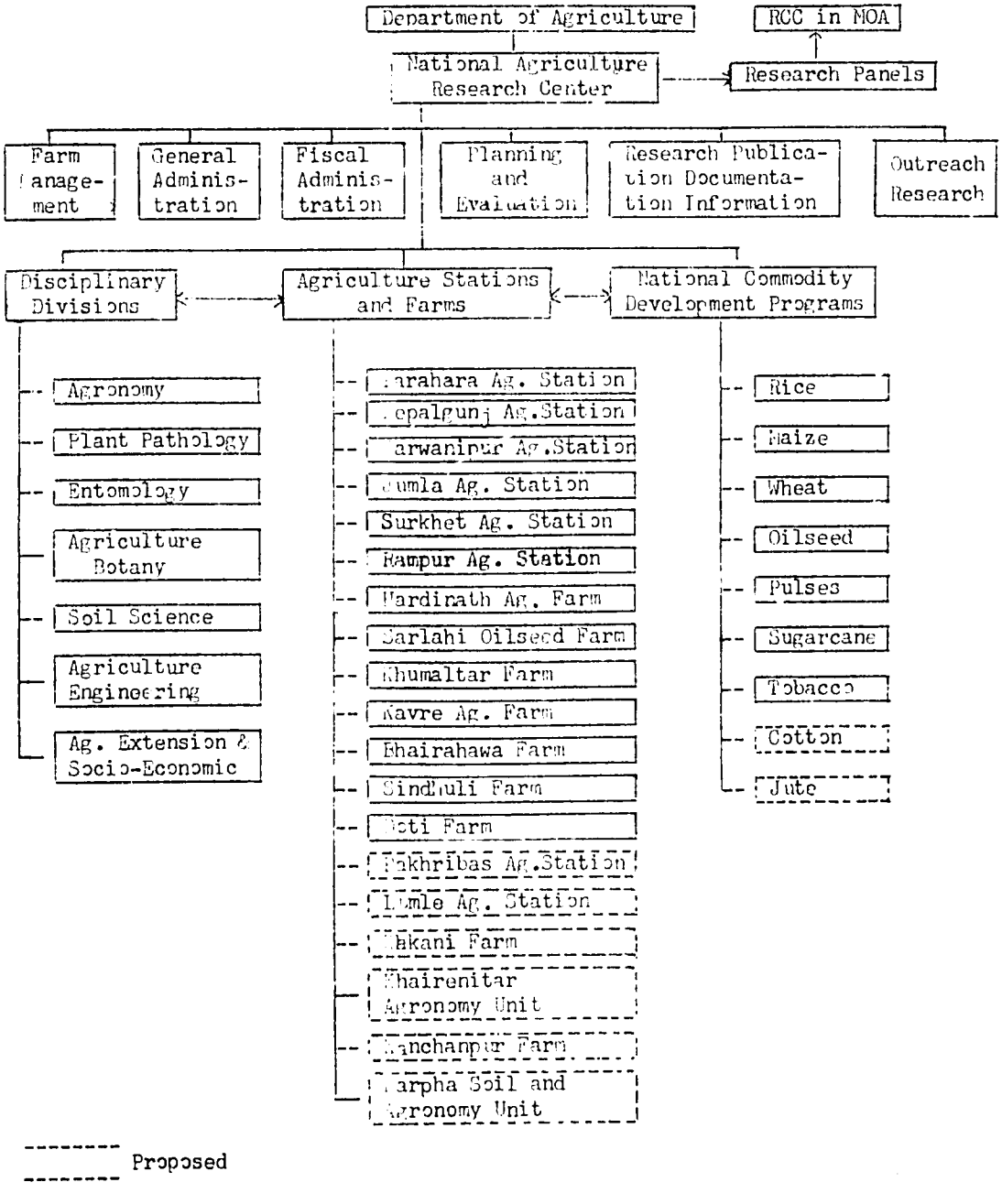
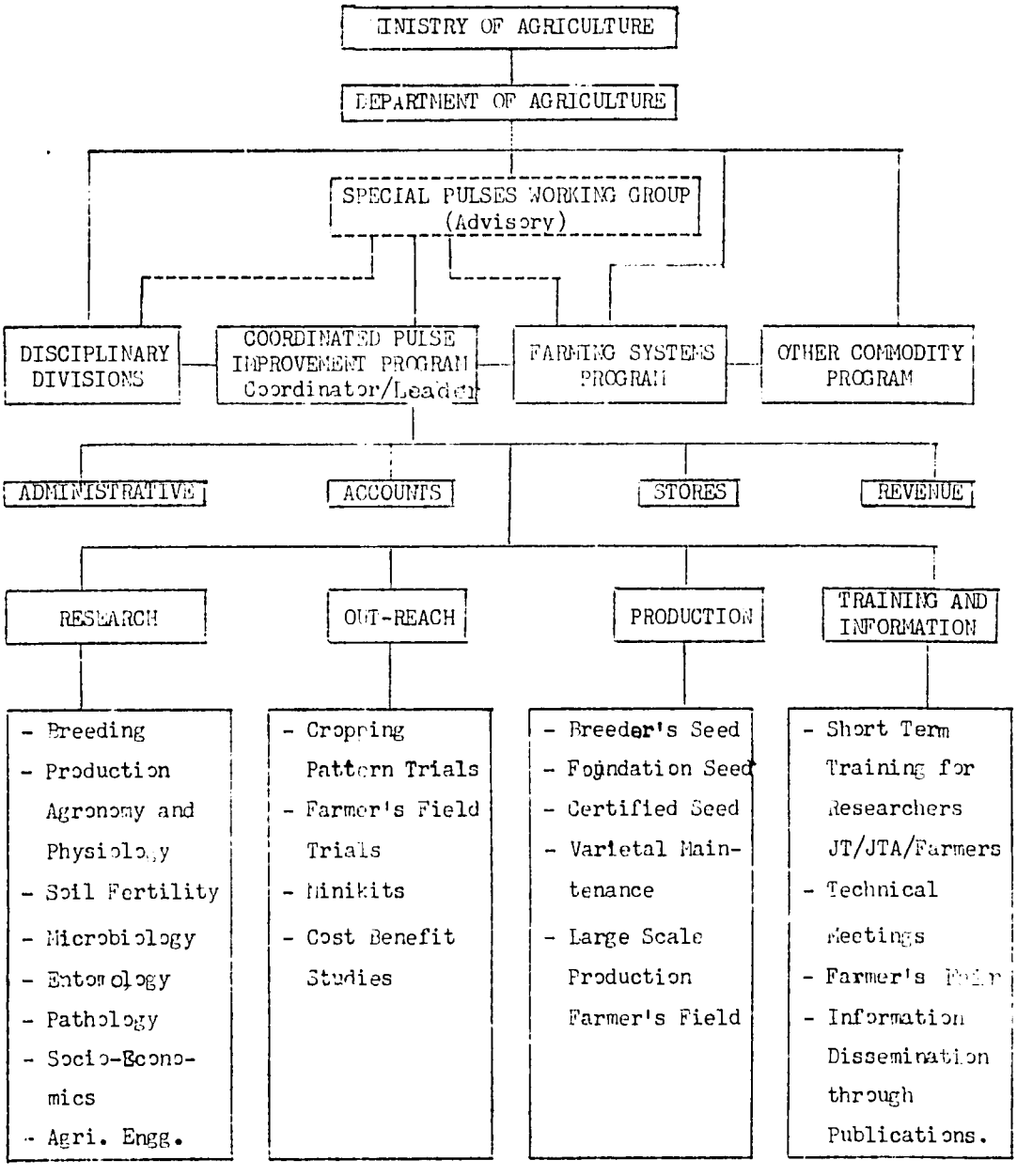


Figure 2: Pulse Program Institutional Framework and Functions



Operational Sites

Main center and headquarters for the pulses program will be the Sarlahi station at Nawalpur which will be shared with the oilseeds program and adjoins the Horticulture Farm, partially supported by the Japanese Agriculture Development Program headquartered at Janakpur. Elevation is about 100 m. and rainfall is 1500 mm. Up to about 50 ha of land will be available at Sarlahi, of which about 7 ha are cleared, levelled and ready for planting. The station does not yet have water - either for domestic use or for irrigation, but a 12-inch diameter, 67-meter deep tubewell is available for irrigation when pump and motor are installed. Electric power from a nearby high tension line should be available when a substation serving that area is constructed - perhaps within 1 or 2 years. Buildings are also urgently needed for both Pulses and Oilseeds and will be provided in part through USAID funding under the New Agricultural Research and Production Project (ARPP).

Secondary Centers. The Khumaltar Research Complex at Kathmandu is proposed to serve temporarily as the headquarters and main center for pulses until the Sarlahi station is fully functional as it would be counter productive to move staff to Nawalpur until facilities are provided there. Thereafter, it is proposed to continue using Khumaltar as a secondary center to serve the Hills and Valleys region, for mid and long term seed storage, and for certain research procedures best carried out there (e.g. microbiology, biochemistry, post harvest studies).

Sub-centers and testing sites. The very success of the Pulses Program with responsibilities for a dozen different species will depend on the ability to carry out research, testing, and verification trials at several agro-ecological

zones. Thirteen established sub-centers have been chosen for this purpose (Appendix 8):

Tarai and Inner Tarai (mainly winter pulses, pigeonpea)

		Elevation (m.)	Rainfall (mm.)
1.	Kankai Agricultural Farm, Jhapa	2064	3000
2.	Tarahara Agricultural Station, Sunsari	200	1700
3.	Hardinath Agricultural Station, Janakpur	93	1600
4.	Parwanipur Agricultural Station, Bara	115	1150
5.	Rampur Agriculture Station, Chitwan	228	2000
6.	Bhairahawa Agriculture Station, Rupendehi	120	2000
7.	Nepalgunj Agriculture Station, Banke	190	1300

Hills and Valleys (mainly summer legumes):

1.	Pakhribas Agriculture Center, Dhankuta	1760	2250
2.	Kabhre Agriculture Farm, Kabhre	1700	1900
3.	Lumle Agriculture Center, Kaski	1675	5100
4.	Doti Agriculture Farm, Doti	620	903
5.	Surkhet Agriculture Farm, Surkhet	450	1500
6.	Jumla Agriculture Station, Jumla	2507	600

Collaboration with FSR. It is also proposed that pulses collaborate closely with Farming Systems Program both to help develop new innovations and as a final evaluator of advanced technologies. The principal farming systems sites overlap but complement the sub-center network and include:

		Region	Elevation (meters)	Rainfall (mm.)
1.	Chauri Jhari, Rukum	MW	700	1100
2.	Pumdi Bhumdi, Pokhara	W	1000±	4000
3.	Khumaltar, Kathmandu	C	1360	1200
4.	Khandbari, Sankhusava	E	730±	1200
5.	Ratna Nagar, Chitwan	C	305	1000
6.	Bahuvari, Parsa	C	150	1500
7.	Sukchaina, Parsa	C	150	1500

These sites will be increased to 14 locations during the Seventh Five-Year Plan.

Farmers' field trials. Other testing and verification trials would be carried out on selected farmers' fields (FFT's) depending on specific purposes and needs. The numbers and sites of FFT's would vary depending on program development and other factors. Seeds and minikits would, of course, be distributed separately to extensionists, production specialists and farmers. In all cases the program should seek feedback on local reactions to new technologies and varieties however distributed.

Pulses Working Group

The formation of a special Pulses Working Group (PWG) is strongly recommended. The purpose of this group is to advise on technical matters, help prioritize problem areas, and decide on the annual allocation of the Special Projects Fund for adjunct studies in other divisions and departments. Membership in the Group should include those divisions and other agencies whose expertise and facilities are needed by pulses. If possible, Division Heads should serve as members; otherwise they should appoint designees to serve in their stead. Thus, membership should include:

1. Agronomy
2. Soil Science
3. Plant Pathology
4. Entomology
5. Agriculture Botany
6. Agriculture Engineering
7. Socio-Economics
8. Extension
9. Farming Systems Program
10. Seed Industry (Agricultural Inputs Corporation)
11. Farmers' Groups
12. DOA Representative (DDG for Crops)
13. Other Organizations or Groups (ad.hoc.)

If possible, the Deputy Director General for Crops could serve as Chairman, while the Pulses Coordinator could act as secretary. Of course, representatives of other organizations and agencies (eg. experiment stations, horticulture, forestry, livestock and others) may be invited on an ad.hoc. basis as needed.

Meetings should be held twice a year at the beginning of the two major seasons. The usual order of business could be as follows:

1. Brief review of past season's results by members of the Pulse Program.
2. Cropping systems studies with pulses.
3. Results of relevant experiments on pulses from disciplinary divisions and other agencies.
4. Presentation of future plans by the Pulses Coordinator.
5. Discussion of current problem areas and recommendations.

6. Allotment of Special Projects Fund. A more orderly and expeditious procedure for allocating these funds would be through an "Executive Committee" comprised of two rotating members with a permanent secretary - the Pulses Coordinator.

7. Visits to the field and laboratories (as appropriate).

Meetings may be held wherever convenient, but different centers with special or interesting results would offer advantages for viewing new developments. At the outset it may be necessary to allow 2 or 3 days for meetings, but later it may be possible to finish in 1 or 1½ days.

Multidisciplinary Approach.

The team approach to complex plant improvement problems has been shown clearly superior to individual or discipline oriented research. It helps focus attention of researchers with diverse talents and training on the most important problems, ensures intra-program participation by all members of the team, and allows better prioritization of activities and resources.

Although the team-work concept is well accepted, it often receives only lip service in practice. Too frequently, researchers become deeply involved in solving their own problems and do not welcome outside interference. Moreover, their academic background has been highly discipline oriented and not conducive to collaborative activities. Therefore, implementing the multi-disciplinary approach requires the genuine desire and good inter-personal relationships by all members. It also requires constant attention and hard effort by the leader/coordinator. One way to foster and encourage interdisciplinary collaboration is to create informal technical

groupings within the program. These groups should meet and work together on functional areas or "thrusts" where specific disciplines are relegated to secondary roles. For example, the following groups would be most important at the outset.

1. Plant Improvement. Chaired/moderated by a senior plant breeder; to include plant protection specialists, agronomists, physiologists, biochemists (if any), socio-economists.

2. Crop Growth/Management. Chmn: agronomist, physiologist, microbiologist or soil scientist. Other members: entomologists; pathologists, breeders, socio-economists, others.

3. Plant Protection. Chmn: pathologist or entomologist. Others: plant breeders, agronomists, soil scientists and others.

Other groupings might be established as needed: for example, (i) Product Quality: biochemists, ag-engineers, breeders, socio-economists, plant protectionists, others; (ii) Outreach/Extension: socio-economists, allied extensionists, plant breeders, agronomists/soils, plant protectionists, others; (iii) Mechanization: engineers, agronomists/soils, socio-economists, breeders and others. These groups need not organize frequent regular meetings, except for seasonal planning. Rather, the best and most effective get-together could be in the field or laboratory to observe and discuss problems as they occur and jointly decide on a course of action. It is assumed the Pulses Coordinator would be a working scientist and would attend most group meetings. He/she should also organize regularly scheduled, all-program meetings more frequently in the early stages (e.g. every week), but not less frequently than once a month. Whenever possible, outsiders from other

divisions,, stations and agencies (e.g. horticulture, botany, extension) should be invited to both the group and program meetings.

Planning. The planning process is critical to the multi-disciplinary approach. It must be done carefully and reflect the collective wisdom of the entire program as well as any key outsiders who can be coopted for the process. It is recommended that planning be done twice annually (for the two major seasons) and according to a three-step procedure:

1. Initial preparation: Detailed plans are drawn up by individual scientists/heads of sections.
2. Group review: Plans prepared by section heads are presented to the respective groups (e.g. plant pathologist plans reviewed by the plant protection group). Plans are modified and improved as per agreed upon comments and suggestions.
3. Program review: Plans and proposals screened by the respective groups are consolidated by the coordinator and presented to the Special Pulses Working Group (described previously).

This planning procedure should be aimed at prioritizing problem areas, focussing attention on major issues, eliminating irrelevant/unproductive experiments or activities, and avoiding duplication. It will help assure a higher standard of individual performance, and foster a spirit of cooperation amongst the team members.

Wherever possible, experiments and other plantings should be used as efficiently as possible. For example, the germplasm collections and breeder's nurseries should be evaluated

for several purposes: (i) disease reaction by pathologists; (ii) pest reaction by entomologists (if not protected); (iii) nodulation by the microbiologists; (iv) tolerance of drouth, water logging, pH extremes, Al tolerance, growth habit etc. by physiologists, agronomists and soil scientists.

Execution. Poorly carried out experiments and plot work cannot be tolerated under any circumstances; particularly in a resource - poor program. Suboptimal seed bed preparation, untimely plantings, low seed viability, failure to inoculate (if needed), inadequate weed control, sub-marginal water management, and lack of pest control are some of the factors resulting in gappy stands and unhealthy growth. The data are unreliable and staff time and limited resources are wasted. The point is that all details of conducting field experiments and trials are crucial and cannot be left up to low paid staff and laborers to carry out. The scientists themselves must oversee and carefully supervise all aspects of crop husbandary in their own experiments and trials.

Forging External Linkages.

All available technology should be sought from other international and national improvement agencies. Nepalese researchers should begin with the state-of-the-art technology and not attempt to 'reinvent the wheel'. The most helpful organizations are the international research centers like ICRISAT, ICARDA, IITA, CIAT and AVRDC. Their mandate is to serve countries like Nepal. However, it is not necessary to accept complex and expensive-to-carry-out experiments or trials from any external agency unless it is clearly in the national interest to do so. Therefore, pulse researchers should determine what they really want and need from the full range of offerings available. The best bargains are specialized

nurseries including segregating lines from which legume breeders may select adapted, desirable genetic materials; the vast amount of informational materials generated each year; and training programs. Linkages to the several IARC's should be pursued aggresively to assure getting on their mailing lists. In addition IARC representatives should be invited to Nepal at every opportunity, and individual pulse scientists should seek to know and communicate with their counterparts at the IARC's.

Coordination

The most feasible short term arrangement will be to include all crops under one umbrella - the Coordinated Pulses Improvement Program. This allows integration of staff and resources, and focussing them on the most urgent problems of grain legume improvement in the country. However, the large number of diverse crops involved will quickly become too complex and difficult to effectively coordinate as a single entity. It is therefore proposed that during Phase II pulses should be subdivided into two over-lapping sections, each with a working scientist as joint coordinator, but closely linked together under an overall, full time coordinator. The two natural divisions proposed are:

1. Tarai Pulses. This would include mainly the winter species: lentil , chickpeas, grasspea , and fieldpea but also summer species like pigeonpea, horsegram, cowpea, and mungbean.

2. Hill Pulses. Mainly summer legumes, especially soybean, cowpea, blackgram, mungbean, horsegram, and Phaseolus bean (at higher elevations); and winter species where they can be grown: lentil chickpea, broadbean grasspea, and fieldpea (upper hills).

This division of labor should allow legume scientists to specialize on a more homogeneous groups of crops with similar problems and uses. It should also prove more efficient in terms of travel, field experimentation, and dealing with diverse production problems.

Training

Training is an essential aspect of institutional development and must be continued indefinitely. However, it will be particularly critical at the outset to train young scientists and technicians thereby enabling the new program to become functional as quickly as possible. Training goals at the postgraduate, group, and in-service levels for Phase I and II are briefly outlined below:

Phase 1 (1985/1990) training

1. Postgraduate to be carried out mainly in India and the Philippines with theses problems to be done at IARC's or in Nepal:

	m/m
- Agronomy (1 PhD and 3 MSc's)	108
- Pathology/Entomology (2 PhD's and 1 MSc)	96
- Breeding (1 PhD and 2 MSc's)	84
- Microbiology (1 PhD)	36
Total = 5 PhD's and 6 MSc's	ST 324

2. Group training--workshops, seminars, study tours:

- Within Nepal and India	25
- International workshops and conferences (4 pers. x 1 month x 4 years)	16
ST	41

3. In-service training at IARC's (2 per year x 3 months each x 5 years) ST 30

Phase II (1990/2000) training:

Training must continue throughout the 1990's and beyond. In fact, it will be necessary to increase the level of training, particularly at the postgraduate level, to meet the expanding needs of the three programs. Phase II projections (10 years) are:

		m/m
1.	Postgraduate:	
	- Agronomy (2 PhD's and 2 MSc's)	120
	- Pathology (2 PhD's and 1 MSc)	96
	- Entomology (1 PhD and 2 MSc's)	84
	- Breeding (2 PhD's and 2 MSc's)	120
	- Physiology (1 PhD and 1 MSc)	60
	- Socio-economics (1 PhD and 1 MSc)	60
	- Biochemistry (1 PhD or MSc)	36
	Total = 9 PhD's and 10 MSc's	ST 576
2.	Group training:	
	- Within country (monitoring trips, etc.)	50
	- International (workshops/seminars)	55
		ST 105
3.	In-service training:	
	- At IARC's: 3 to 4 per year x 3 mo.	120
	- National institutions (e.g. India)	50
		ST 200

V. OPERATIONAL STRATEGIES

The most important first step toward increasing pulse production will be institutional specifically establishing a fully supported Coordinated Pulses Improvement Program (CPIP), together with the necessary production support including the involvement of extension, seed production, credit agencies and integrated community development projects (like IRDP). Assuming the institutional aspects have been resolved, (see Section IV), the direct constraints - physical and biotic - can be addressed. The next step is to define the primary goal and objectives and scope of the program.

GOALS AND OBJECTIVES

The primary goal and major objectives of the Coordinated Pulses Improvement Program are proposed following World Bank recommendations in a recent agriculture sector review. The primary goal would be:

"To increase and stabilize production and productivities of pulses in Nepal".

Major objectives and scope of the program will naturally follow this goal and would include:

1. To generate appropriate technologies to raise grain legume production by coordinating all research activities in a multi-disciplinary approach.

2. To organize an ongoing system of testing and verification of relevant technologies in farmers' fields in the different agro-climatic regions.

3. To coordinate and participate in all activities relevant to legume improvement and production in various districts of Nepal.

4. To maintain improved legume varieties and the breeder's source/seeds needed for the dissemination of improved varieties.

SPECIFIC OBJECTIVES

Specific objectives for research can be formulated based on an intimate knowledge of the problems, farmers' needs, the genetic materials available, research progress already made (the literature), and program capabilities. It is not always possible nor prudent to simultaneously mount investigations on all major problem areas when the program is just becoming established, staff is not yet recruited nor adequately trained, facilities are not functional, and institutional linkages are not established. A better approach is to phase program activities in two steps; short and long term or Phase I (1985/1990) and Phase II (1990/2000).

Phase I (1985/1990) Objectives.

Most of the short term pulse program objectives are fundamental and continuing, although some activities will trend to decline in importance over time. They include the following:

1. Genetic improvement. Collect, introduce, maintain, evaluate and test basic germplasm from both local and exotic sources. Select and recombine elite lines to increase yield and productive stability, incorporate pest resistance and stress tolerance, and improve agronomic characteristics (e.g. earliness, standability, shatter resistance, robust growth) and product qualities. Initially, emphasis will be given to soybean, mungbean, blackgram, cowpea, pigeonpea, lentils and chickpea.

2. Plant protection. Primary emphasis should be given to evaluating the germplasm to identify host plant resistance to the major pests/diseases of pulses; to participate with plant breeders in screening segregating materials for resistance. Concurrently, appropriate pest control measures need to be developed; and lastly, to carry out surveillance of legume pests/diseases as time permits (low priority).

3. Cultural practices. Develop optimal production practices from tillage/sowing to harvest for the major pulses (see no. 1 above) and for the range of growing conditions and uses expected in Nepal, including irrigated lands. Concurrently, assess costs of production and the comparative advantage of legumes versus other crops.

4. Plant nutrient requirements. Determine the plant nutrient requirements for pulses growing under a range of agro-ecological conditions in the country; and assess the contributions realizable from the symbiotic N^2-fixing system as affected by species and variety of legume, different strains of Rhizobium, inoculum carriers, soil conditions, and climatic/weather factors.

5. Pulses in cropping systems. Coordinate closely with the Farming Systems Program of ARPP in evaluating the role of pulses in different cropping systems relevant to their agronomic suitability for different growing conditions, acceptability to producers, and economic advantages, if any. Collaborative cropping systems studies would also serve as a late stage evaluation of improved technology and would become a bridge to outreach research and extension activities.

6. Seed production. Assume responsibilities for maintaining and producing nucleus and breeder's seeds of both released varieties and advanced lines (pre-release). Program staff should also help train seed producers to ensure genetic purity and seed quality standards are met. In early stages of production it would be necessary to aid certification agencies in rogueing seed production fields.

7. Strengthening the program. This will include short and long term training of research, extension and production staff and personnel; disseminating information on new varieties and production technology through publications, training, demonstrations and minikit trials; and providing technological support for the pulses production program.

Phase II (1990/2000) Objectives

Longer term objectives would be similar to those for Phase I except for some change in emphasis and the addition of two new thrusts (engineering and biochemistry).

1. Genetic improvement. Local collecting is largely completed; shift emphasis to breeding pulses for yield stability - especially by combining multiple pest resistance into improved strains. Also, add new crops and/or downgrade existing species on the high priority list as dictated by experience and systematic surveys. Other species likely to show potential after about 5 years are: grasspea, horsegram, phaseolus, fieldpea, broadbean, and guar.

2. Plant protection. Expand collaborative efforts (with breeders) to identify and incorporate multiple pest/disease resistance into improved strains and varieties. Shift emphasis to integrated pest management using moderately tolerant host plants (if available) together with alleviating cultural practices, biological controls, and minimal use of chemical pesticides.

3. Cultural practices. Continue current program about as it is; but expand research on minimal tillage methods, alley cropping, and use of herbicides for

both initial land preparation (general) and subsequent weed control (selective). Expand socio-economic studies on cost/benefit analysis of new technologies.

4-7 Continue as in Phase I taking account of new developments and any shifts in program priorities - especially with regard to species.

8. Mechanization. Initiate studies on post harvest handling, especially more effective drying, threshing and storing. Link up with agronomists in studies on more efficient tillage methods and the use of herbicides. Whenever possible study appropriate mechanization, particularly the uses of knapsack sprayers (for primary 'tillage' and weed control), improved or drawn equipment, small (2 - wheel) powered tillers, simple threshers, and small seed dryers (IRRI type).

9. Product quality. Evaluate both cooking and nutritional qualities of pulses as affected by species, genotype, environment, and management/handling. Special emphasis should be given to reducing or eliminating toxic or anti-nutritional principles - especially in grass-pea (lathyrism), horsegram, phaseolus and soybean. Other important objectives are to reduce cooking times to save fuel; and study aspects related to using pulses and their aftermath for animal feeds.

PRIORITIZATION OF OBJECTIVES

An essential aspect of planning is the prioritization of specific objectives. Although the relative importance of different program activities is constantly implied, comparative rankings are clearer and better understood in tabular form.

Therefore, tentative proposals to rank pulses improvement objectives are separately outlined in the following text tables:

TABLE	FUNCTIONAL AREA
5	Plant improvement
6	Management and plant growth
7	Plant protection
8	Socio-economics
9	Product quality

Some Operational Guidelines

The complexity and number of legume species included in the new pulses program preclude using the same procedures and strategies as adopted for the major cereals. Instead, the following guidelines are recommended:

1. Focus major attention on a relatively few species which are likely to have the greatest impact for Nepal within a limited time frame.
2. Limit activities on 'secondary' species to testing a modest number of highly elite lines at a few locations.
3. Borrow all available technology on the principal species from whomever can supply it but especially from the IARC's.
4. Organize all major improvement activities on a multi-disciplinary basis to assure that each aspect of work receives in-depth study.
5. Plan carefully year-round activities and carry-out well managed experiments and trials over a diverse range of agro-climatic conditions.

These guidelines, if followed, should ensure the Pulses Program will make optimal use of limited staff and resources to make a significant impact on pulse production in Nepal.

Table 5: PROPOSED RESEARCH PRIORITIES FOR PLANT IMPROVEMENT IN MAJOR GRAIN LEGUMES DURING 1985 To 2000

Crop	Selective collecting	Systematic collection	Introduction	Observation Evaluation	Varietal Testing	Recombination	Selection	Remarks
					PHASE - I			
WINTER:								
1. Lentils	•		•••	••	•••	••	•••	Collaborate with ICARDA
2. Chickpea	•		•••	••	•••	••	•	Collaborate with ICRISAT
3. Grasspea	•		•	•	•		•	Defer to Phase II
4. Fieldpea	•		•	•	•		•	Defer to Phase II
5. Broadbean	•		•	•	•		•	Promising for Kathmandu valley.
SUMMER:								
6. Soybean		•••	•••	•••	••	•••	•••	Collaborate with AVRDC, IITA and INTSOY.
7. Blackgram	••		•••	•••	••		•••	Collaborate with India.
8. Mungbean	•		••	••	•••		•	Collaborate with AVRDC and India.
9. Horsegram	••		•	•			•	Collaborate with India.
10. Pigeonpea	•		•••	•••	•••		•••	Collaborate closely with ICRISAT.
11. Cowpea	•		••	••	•••		•	Collaborate with IITA and IRRI.
12. Phaseolus	•		•	•	•			Collaborate with CIAT.
					PHASE - II			
WINTER:								
1. Lentils		•••	•••	•••	••	•••	•••	Systematic collecting with IBPGR.
2. Chickpea	•		•••	••	•••	•••	••	Continue with ICRISAT
3. Grasspea		•••	••	••	••		••	Expand research if justified by survey.
4. Fieldpea		••	••	••	••		•	Expand if justified.
5. Broadbean		•	••	••	••		••	Expand improvement if crop spreads.
SUMMER:								
6. Soybean			••	••	•••	•••	•••	Continue as high priority crop.
7. Blackgram		•••	••	•••	••	•	••	Collaborate on international testing (IDRC)
8. Mungbean		•••	•••	••	•••		••	Continue at same level as in Phase I (with AVRDC).
9. Horsegram		•••	••	••	••		•	Expand improvement if justified by survey.
10. Pigeonpea	•		•••	••	•••		•••	Development of new forms (ICRISAT) will increase production.
11. Cowpea	•		•••	••	•••		••	Cowpeas will find an important niche in farming systems.
12. Phaseolus	•		••	••	•••		••	New types from CIAT will increase in popularity.

Table 6: PROPOSED PRIORITIES FOR MANAGEMENT AND PLANT GROWTH RESEARCH IN GRAIN LEGUMES DURING 1985 To 2000

(* = Low priority; ** = Medium priority; *** = Highest priority)

Crop	Sowing Date	Plant Density	Water Irrigation	Plant Nutrition 6/	Tillage conservation	Weed Control	Cropping pattern	Seed Treatment	Rhizobium strains	Inoculum Carriers	Mechanization/ Harvest
					PHASE - I						
WINTER:											
1. Lentils	*	*	***	***	***	*	**	*	***	***	
2. Chickpea	*	*	***	***	***	*	**		***	***	
3. Grasspea							*		*	*	
4. Other Species 1/	*	*			*		*				
SUMMER:											
5. Soybean	**	***		**	***	***	***	***	***	***	
6. Blackgram	**	**			***	***	**	*	***	**	
7. Mungbean	**	**	***			***	*	*	***	**	
8. Cowpea	**	**	***	*	**	**	***	*	**		
9. Pigeonpea	**					**	***		**		
10. Other Species 2/	*	*			*	*	**		*		
					PHASE - II						
WINTER:											
1. Lentils	*	*	**	**	***	**	**	*	**	*	***
2. Chickpea	*	*	**	**	***	**	*		**	*	**
3. Grasspea 3/	*	*	*		**		**		*		
4. Broadbean		*	**	*	**	*	**		**		
5. Others 4/	*	*	*	*	*		**		*		
SUMMER:											
6. Soybean	**	***		**	***	***	**	*	**	*	***
7. Blackgram	**	*		*	**	***	***	*	**		***
8. Mungbean	**	**	**	*	**	**	**	*	**		***
9. Pigeonpea	*	*		*	**	*	***		**		**
10. Cowpea	**	**	**	**	***	**	***	*	**		**
11. Horsegram 3/	*	*			*		**		**		
12. Others 5/	*				*		**		*		

1/ Includes broadbean and fieldpea;
2/ Other summer species: horsegram, phaseolus, guar;
3/ Continue research on grasspea and horsegram only if justified by survey and experience;
4/ Includes fieldpea;
5/ Includes Phaseolus bean, rice bean, guar;
6/ Includes post legume residual effect.

Table 7: PROPOSED PRIORITIES FOR PLANT PROTECTION RESEARCH IN GRAIN LEGUMES DURING 1985 To 2000

(* = Low priority; ** = Intermediate priority; *** = Highest priority)

Crop	ENTOMOLOGY					PLANT PATHOLOGY				NEMATOLOGY		
	Surveil-lance	Identi-fication	Yield Loss	Screen-ing	Control Measures	Surveil-lance	Identi-fication	Screen-ing	Control Measures	Surveil-lance	Screen-ing.	Control Measures
PHASE - I												
WINTER:												
1. Lentils/Chickpea	**	*	**	***	***	**	*	***	***	**	***	**
2. Other Winter Spp.	*	*	*	**	**	*	*	**	*	*	**	*
SUMMER:												
3. Soybeans	*	*	*	***	**	**	*	***	***	**	***	*
4. Blackgram/Mungbean	*	*	*	***	**	*		***	**	**	***	*
5. Pigeonpea	**	*	**	***	**	**		**	*	*	**	*
6. Other Summer Spp.	*			**	*	**		**	*	*	*	
PHASE - II												
WINTER:												
1. Lentils/Chickpea	*		*	***	**	*		***	*	*	***	*
2. Other Winter Spp.	*	*	*	***	**	*	*	**	*	*	**	
SUMMER:												
3. Soybeans	*	*		***	**	*		***	*	*	***	
4. Blackgram/Mungbean	*			***	**	*	*	***	*	*	***	
5. Pigeonpea	*			***	**	*		***		*	**	
6. Cowpea	*	*	*	**	**	*	*	***		*	**	*
7. Other Summer Spp.	*	*		*	*	*	*	**		*	*	

Table 8: PROPOSED PRIORITIES FOR SOCIO-ECONOMIC RESEARCH ON GRAIN LEGUMES 1985 to 2000

* = Lowest Priority;
** = Intermediate;
*** = Highest Priority.

	Crop	Survey of Trends	Data Collection	New Technologies	Farmer Motivation	Production Economies
				PHASE - I		
1.	Grasspea	***				*
2.	Blackgram	***				*
3.	Winter Spp.	*	**	***	**	***
4.	Summer Spp.	*	**	***	**	***
5.	Systems	**	**		**	***
				PHASE - II		
1.	Winter Spp.	*	**	***	*	***
2.	Summer Spp.	*	**	***	*	***
3.	New Spp.	***	*	**	**	*
4.	Systems	**			**	*

Table 9: PROPOSED PRIORITIES FOR PRODUCT QUALITY RESEARCH ON GRAIN LEGUMES PHASE II ONLY (1990 To 2000)

* = Low Priority,

** = Intermediate,

*** = Highest Priority.

Crops	PREPARATION[1/] Cooking Time	Acceptability	NUTRITIONAL VALUES[2/] Grain	Vegetables	Fodder	Remarks
WINTER:						
1. Lentils	***	***	***		**	As consumed: Split grain
2. Chickpea	**	***	**	*	*	Whole seeds
3. Grasspea	**	*	**		*	Screen for VOAA (if justified)
4. Other Spp.	*	**	*	*	*	'Emerging' species only.
SUMMER:						
5. Soybean	*	*	*	*		Mainly as adjust to management
6. Blackgram	***	**	**		*	Whole, unhusked seeds.
7. Mungbean	***	***	**		*	As consumed
8. Horsegram	**	***	**		**	Screen for antimetabolites (If justified)
9. Cowpea	**	**	**	**	**	Determine local preferences
10. Pigeonpea	**	*	**	**	*	As consumed
11. Other Spp.	*	**	*	*	*	Only if warranted

1/ These evaluations would be carried out on selected diverse germplasm and on advanced breeding lines at the outset.

2/ Proximate principles -e.g. crude protein, fats and carbohydrates on basic germplasm; more complete valuations of amino acids and minerals on diverse genetic stocks and advanced lines.

FORMULATING A WORKPLAN

An understanding of the constraints together with a knowledge of research methodologies and program capabilities provide the basis for designing operational strategies. With this background it is possible to formulate a detailed workplan probably twice a year. This requires detailed knowledge of previous investigations carried out, research station resources, staff and labor capabilities, equipment availability, operational costs involved, seeds on hand, and other factors. Once started, a workplan is easier to prepare and tends to 'feed on itself'. However, it is essential to continuously question the process, strive to improve it, and submit the proposals to a jury of peers (e.g. Pulses Working Group). This will help focus a much wider range of experience and interest on the major problems and their solution.

Preparing a workplan is particularly difficult in the early stages of development. Therefore, some suggestions on "Formulating A WORKPLAN" are outlined in Appendix 9. These should be considered more as broad guidelines rather than as a structural basis for program operations.

VI. FACILITIES - STAFFING - BUDGET

The facilities, equipment, personnel and operating budget necessary to establish and operate the Pulses Program is projected separately for Phase I and II. However, most of the construction, equipment and furnishings are budgetted during the first five years.

PHASE I DEVELOPMENT

Two main centers will be needed for pulses improvement. The first and primary coordinating center at Nawalpur (Sarlahi) will also serve the Tarai and Inner Tarai. The second center will support the research needs of the Hills and Valleys regions. It is presumed that work for the mid-elevations (up to about 2000 m.) can continue at Khumaltar where investigations on pulses have been carried out since 1972/73. However, much testing and other experimentation will need to be carried out at several (13) Tarai and Hill stations as noted previously (Section IV). These and other activities would also be done in collaboration with Farming Systems at selected sites. Another option should receive increasing attention - testing and verifying technology on farmers' fields - to better represent real growers' conditions and the diverse agro-ecological regions of the country.

A. Staffing and Personnel

The proposed staff and personnel for the Pulses Program follows closely the original Bharati (1985) paper:

1. Gazetted Researchers

	Post	Starting Year	Amount Rs.'000
- G - I	: Coordinator	1	220
- G -II	: Agronomist (2)	1+2	270
	: Plant Breeders (2)	1+2	270
	: Soils Scientist (2)	2	240
	: Plant Pathologist (1)	2	120
	: Entomologist (1)	2	120
- G-III	: Asst. Agronomist (8)	1-5	642
	: Asst. Prod. Agronomist (3)	3-5	120
	: Asst. Ext. Agronomist (1)	3	60
	: Asst. Soils Scientist(1)	4	36
	: Asst. Plant Pathologist (1)	3	60
	: Asst. Entomologist (1)	2	84
	: Asst. Agric. Economist (1)	3	60
	: Asst. Agric. Engineer (1)	2	84
	Sub-Total	26	Rs.2,386

2. Non-gazetted Research Support

NG-I	: Junior Technician (12)	2-5	580
	: Mechanic (1)	2	60
NG-II	: Jr. Tech. Asst. (3)	1+3	160
	: Tractor Driver (1)	2	48
NG-III	: Drivers (2)	1+2	90
	: Field Assistants (11)	1-5	380
	Sub-Total 30		Rs.1,318

3. Administration/Permanent labor

	Post	Starting Year	Amount Rs.'000
- G - III:	Section Officer (1)	2	90
- NG- I:	Accountant (1)	1	70
- NG- II:	Accountant (1)	2	40
:	Admin. Assistant (1)	1	50
:	Store Keeper (1)	1	50
:	Peons, (2)	1	16
:	Guards (8)	1+2	270
:	Laborers (15)	1+2	540
	Sub-Total 30		Rs. 1,132

4. Field Labor (casual) 100

Total: Perm. staff = 86 5 year Cost=Rs. 4,936

B. Construction and Station Development

Main Centers. Virtually no construction would be required at Khumaltar; but considerable development will be needed at Sarlahi as proposed by Bharati (1965):

	Construction	Rs.'000
1.	Office and coordinator's building	5,500
2.	Residence: 4 duplexes	2,000
3.	Two-story residence duplex	5,000
4.	Threshing floor, garage, workshop, etc.	1,250
		ST = Rs.13,750

In addition, some farm and facility development specifically for pulses would be required at Sarlahi:

	Station Development	Rs.'000
1.	Fencing (internal-around plots/experiments)	125
2.	Land development/irrigation, etc.	150
3.	Glass houses*	800
4.	Screen houses/head house	400
		Rs. 1,475

*Fully-glassed houses are unusable in torrid climates. These should have glass roofs (with overhang),top vents and mesh sides.

Sub-centers. It will also be necessary to make some provision for small field laboratories (threshing, seed and plant evaluation) and for storing equipment, seeds and supplies, at the sub-centers. The following is proposed.

	Construction	Rs.'000
1.	Larger sub-centers: Rampur, Nepalgunj and Kabhre	Rs. 300
2.	Smaller sub-centers/testing sites 7 x Rs.100,000	Rs. 700
	Sub Total	Rs.1,000

Some additional construction at sub-centers may be deferred until Phase II.

Basic station development. Several basic developments will be needed at Sarlahi to serve not only NPIP, but also oilseeds, other projects located there, and for general functioning of the station. These must be arranged for and purchased locally (or in India).

	Item	Estimate Rs.'000
1.	Boring a tubewell (6" or 8") for domestic water supply	100
2.	Small water pump (electric) and overhead tank for domestic water	70
3.	Large earthen holding tank for irrigation water	80
4.	Electrical connection w/transformer from high-tension line to station*	100
5.	Large electric water pump for irrigation (12" bore)	250
6.	Irrigation tubes, connections, valves etc.	90
7.	Farm stores and field laboratories	1,650
8.	Testing of water quality and well flow capacity (irrigation)	30
	Total	Rs.2370

*Diesel powered generators are not a satisfactory source of primary energy on account of difficulties in maintenances and operational costs. Therefore, purchase of a diesel generator is not recommended until the need for stand-by power is ascertained.

C. Non-Expendable Equipment

This category includes vehicles and farm equipment, laboratory equipment, and office equipment/furnishings.

Vehicles & farm equipment. This list has been modified somewhat relative to the Bharati proposal. Some minor changes are made in the first 12 items; and basic station development

equipment (water pump, generator, and transformer) have been transferred to another category - Basic Station Development. The new list, intended mainly for Sarlahi and the sub-centers, is organized as follows:

	Item	Estimate Rs.'000
1.	Small pickup trucks: Toyota diesels (2)	Rs. 39[illegible]
2.	Large tractor (245 h.p.) w/equipment (1)	400
3.	Small (2 wheel) tractors w/equipment (4)	400
4.	Motorcycles (6) and bicycles (10)	140
5.	Single plot threshers - small (8)	320
6.	Bundle thresher - large; for Sarlahi (1)	100
7.	Seed driers, IRRI type (2)	50
8.	Seed cleaners, graders (2)	50
9.	Sprayers, hand (16)	16
10.	U-vac machines (2)	20
11.	Bench type seed cleaners (4)	20
12.	Bench type bean threshers (2)	20
13.	Sweepnets (10)	1
14.	Seed counters (2)	12
15.	Airconditioners (2) and room dehumidifiers (2)*	60
16.	Miscellaneous: magnifiers, standard sieves other small instruments	11
	Sub-total	Rs.1,9[illegible]

*For short and medium term seed storage.

This proposal strongly recommends procuring two small diesel pickups (Toyota) rather than one pick up and a personnel carrier as pickups have much more practical utility than a 'jeep'type vehicle. Moreover, pickups can be easily retrofitted with canvas tops and fold up bench seats that do not interfere with their load carrying capacity.

Three additional 2-wheel tractors are recommended as they provide considerable versatility in preparing and maintaining plots, and for extra farm transport. Moreover, 2 - wheel tractors can be conveniently transported (by pickup) to off-station sites to prepare land for trials and experiments.

All stationary equipment requiring a power source -e.g. threshers, seed cleaners, etc. - should be fitted with electric motors whenever possible, and can usually be so ordered. In situations where an electricity source is unavailable or unreliable these machines could also be retrofitted (in Nepal) with small diesel engines. There already are three single plant threshers at Khumaltar in apparent excellent condition that should be so modified.

Laboratory equipment and furnishings. This list of equipment, instruments, and furnishings is intended primarily for Sarlahi, but some items(e.g. weighing scales, Mettler balances, ovens, incubators and microscopes) will also be used at Khumaltar in Entomology, Pathology and Soils laboratories.

Items	Estimate Rs.'000
1. Weighing scales - 10 kg. capacity (2)	20
2. Mettler top-loading balances (3)	72
3. Laboratory Ovens (2)	50

	Item	Estimated Rs.'000
4.	Incubators (2)	50
5.	Binocular microscopes w/attachments (4)	160
6.	Moisture meters (6)	30
7.	Seed germinators (1)	7[illegible]
8.	Deep freezers - upright, 16 to 20 cu.ft. (4)*	120
9.	Refrigerators - about 12 to 15 cu.ft.(4)**	100
10.	Camera w/attachments (2)	20
11.	Insect cabinets	15
12.	Insect collection boxes	5
13.	Miscellaneous	5
	Sub-Total =	Rs. 722

*For long term seed storage at Sarlahi.
**For storing chemicals, cultures, plants, etc.

Office equipment. This list is intended primarily for Sarlahi and has been modified to include a radio-telephone linkage to Kathmandu and other locations.

	Item	Estimate Rs.'000
1.	Typewriters (2 Nepali and 2 English)	Rs. 30
2.	Photocopy machine (1)	30
3.	Slide Projector w/Screen (1)	1[illegible]
4.	Overhead projector (1)	1[illegible]
5.	Litho-machine, electric and manual (2)	5[illegible]
6.	Radio-telephone linkage to Sarlahi	20[illegible]
7.	Laboratory tables/furnishings	8[illegible]
	Sub-Total=	Rs.1,132
	Total non-expendable=	Rs.3,824

D. Expendable Equipment and Supplies

This includes operational supplies and expendable equipment needed for both field and laboratory research at Sarlahi and the sub-centers during Phase I (5 years).

	Item	Estimate Rs.'000
1.	Fertilizers and soil amendments	Rs. 300
2.	Seeds and inoculums	110
3.	Pesticides and bio-chemicals	50
4.	Bags, string, paper, tapes, tags, labels etc.	120
5.	Spare parts for equipment	130
6.	Plant pots, growing medium	60
7.	Fencing materials for field experiments (internal)	120
8.	Glassware and laboratory supplies	60
9.	Miscellaneous supplies	[illegible]
10.	Office supplies	1[illegible]
	Total =	Rs.1,0[illegible]

E. Operations and Miscellaneous

This category includes support for operation and maintenance of equipment, report printing, travel, and discretionary funds for collaborating departments and stations. The latter item would allow some departments (e.g. Entomology - Pathology - Soils - Botany) and centers/sub-centers to recoup some of their intangible costs in connection with their cooperation on grain legume research, and permit them to carry out some related work on these crops wholly within their departments.

	Item	Estimate Rs. '000
1.	Operation and maintenance of equipment	300
2.	Collaborating departments: backstopping*	675
3.	Travel: special support for in-country travel.	425
4.	Report: printing and sundry expenses	150
	Total =	Rs. 1,550

*Calculated at about Rs.30,000/year each for 3 major departments and Rs.15,000/year for 3 others (departments, centers, sub-centers). Actual amounts should be negotiated each year.

F. Training: Short and Long Term

The cost of training in Phase I is calculated from the targets proposed under "INSTITUTIONAL DEVELOPMENT". It is assumed that post graduate training at the PhD level would require 3 years (36 m/m) beyond the MSc and 24 m/m for MSc. Projected total costs for the first five years are estimated at:

	Kind of Training	Duration m/m	Estimate Rs.'000
1.	Post graduate: 5 PhD's + 6 MSc's	324	1,620
2.	Group training: Nepal/India	25	500
3.	International workshops, seminars, etc.	18	1,440
4.	In-service training at IARC's	30	1,280
		Total =	Rs.4,840

Budget Summary - Phase I

The first five years represent the most critical period for the Pulses Program. Staff must be recruited and trained, major construction carried out, equipment ordered, plans made,

and programs executed. This heavy task, together with providing leadership, guidance to young scientists, and overall coordination, will rest primarily with the coordinator. He and the Program will also be under heavy pressure to produce tangible results earlier than should be expected to gain public support, strengthen staff morale, and assure continuation of the program in Phase II. The magnitude of this challenge can be summarised from the budget summary shown below:

	Category		Phase I (Rs.'000)
A.	Salaries and Allowances		4,936
B.	Construction/station development (GLIP)		
	- Main centers	15,225	
	- Sub-centers	1,000	
	S.T.	16,225	
C.	Non-expendable equipment:		
	- vehicles and farm equipment	1,970	
	- Laboratory equipment/furnishings	722	
	- Office equipment	1,132	
	S.T.=	3,824	
	Total construction/non-expendable =		20,049
D.	Expendable equipment and supplies		1,080
E.	Operations and Miscellaneous		1,550
F.	Training: short and long term		4,840
	Grand Total =		32,455

This assumes that considerable basic station development at Sarlahi will be carried out promptly and funded separately. The cost of this development in support of all programs and activities at that station is estimated at Rs.23.7 lakhs, in addition to the above.

PHASE II

The character of grain legume improvement will evolve over the next 10 to 15 years. Some change in emphasis will occur as certain legume species develop greater potential, while others decline in importance. Therefore, the program strategies must remain flexible.

Early gains expected during Phase I and the first years of Phase II will be rapid and derive mainly from introducing and adapting improved technologies from elsewhere, especially from the IARC's. However, a residue of 'hard core' problems and refinement of existing improvements will require increasing efforts to generate new technologies within the country. Since the most serious production problems are related to plant improvement, it is proposed that one additional gazetted II post, together with three additional gazetted III, and appropriate non-gazetted positions be added to the program in Phase II. There will be an urgent need for more sophisticated studies on product quality, plant processes, growth phenomen and general biochemical analysis by the 1990's. Therefore, a biochemist (the G.II post) is proposed to be added to Pulses during Phase II. This expansion would increase salaries of gazetted staff by 40 to 45 percent during 1990 to 1995; but have lesser implications for the lower categories. An approximation of salary costs in constant Rupees for Phase II (A) and (B) are projected below:

A. <u>Staffing and Personnel</u>

<u>Phase II (A): 1990 to 1995</u>

		Rs.'000
1.	Gazetted researchers	
	(a) Current costs (Phase I)	2,336
	(b) Additional posts = 4 (45% of P.I.)	1,074
	(c) Promotions, other increases (40% of a + b)	1,384
	Sub-Total	Rs.4,844

	Rs.'000
2. Non-gazetted Research Support:	
(a) Current costs (Phase I)	1,318
(b) Additional JT/JTA's (6 x 48.3)	290
(c) Promotions, other increases (35% of a + b)	563
Sub-Total	Rs.2,171
3. Administration/permanent labor:	
(a) Current costs	1,132
(b) Additional laborers (7 x 36)	252
(c) Promotions, other (30% a + b)	415
Sub-Total	Rs.1,799
Phase II (A) Total	Rs.8,814

Phase II (B): 1995/2000

1. Gazetted Researchers:	
(a) Phase II (A) costs	4,844
(b) Promotions, other (40%)	1,938
Sub-Total	Rs.6,782
2. Non-gazetted Research Support:	
(a) Phase II (A) Costs	2,171
(b) Promotions, other (35%)	760
Sub-Total	Rs.2,931
3. Administration/Labor:	
(a) Phase II (A) costs	1,799
(b) Promotions, other (30%)	540
Sub-Total	Rs.2,339
Phase II (B) Total	Rs.12,052
Grand total Phase II Salaries (10 years)	20,866

		Rs.'000
B.	Non-Expendable Equipment	
	1. Vehicle/field equipment - est.	650
	2. Laboratories, general	400
	3. Laboratory - biochemistry	550
	4. Office equipment/furnishings	200
	Total	Rs.1,800
C.	Expendable Equipment/Supplies	
	1. Spare parts for equipment	300
	2. Other supplies	2,400
	Total	Rs.2,700
D.	Operations and Miscellaneous	
	1. Operation/maintenance of equipment	750
	2. Collaborating departments	2200
	3. Report printing/sundry	400
	Total	Rs.3,350
E.	Training - 10 Years:	
	1. Post-graduate: 9 PhD's + 10 MSc's (586 m/m x 8.6)	5,040
	2. Group training:	
	Nepal and India (50 m/m x 20)	1,000
	International (55 m/m x 80)	4,400
	Sub-Total	Rs.5,400
	3. In-service training:	
	- At IARC's (120 m/m x 40)	4,800
	- National institutions, e.g. India (50 m/m x 15)	750
	Sub-Total	Rs.5,550
	TOTAL PHASE II TRAINING	=Rs.15,990

Budget Summary - Phase II.

The projected budget for Phase II (10 years) includes provision for some non-expendable equipment, but not for construction. It is assumed that major construction for pulses will have been completed during Phase I; and that minor facility alterations and maintenance will be included under a separate budget for station operations. A summary of the projections for 1990 to 2000 is as follows:

	Item	Estimate Rs.'000	Percent of Total
A.	Salaries/allowances	20,866	46.7
B.	Non-expendable equipment	1,800	4.0
C.	Expendable equipment/supplies	2,700	6.0
C.	Operations and miscellaneous	3,350	7.5
D.	Training	15,990	35.8
	Grand Total	Rs. 44,706	($2.48 million)

The total budget for Phase II (10 years) is Rs.447.1 lakhs compared with Rs.324.4 lakhs for Phase I. Excluding training, non-expendable equipment and construction, the average annual cost for recurring expenditures increases from Rs.15.1 lakhs to Rs.26.9 lakhs during Phase I and Phase II, respectively. Salaries as a proportion of total recurring expenditures also increase from 65.2 percent to 77.5 percent for Phase I and Phase II, respectively. Most of the increase in salary/allowances costs reflect the increase in research officers and in presumed additional costs for promotions and increments. In any event, the total projected costs of the Pulses Program for both Phase I and II are only Rs.767 lakhs and very modest by international standards.

VII. PROGRAM IMPACT

The coordinated pulse improvement program has excellent possibilities to make a significant impact on grain legume production in the country-once established and adequately supported. There is already a backlog of new technologies available mainly from the IARC's and key national programs -- ready for testing and adapting to Nepalese needs and growing conditions.

PROJECTIONS

Assuming that staff is recruited promptly and trained as scheduled, that facilities requested are provided without delay, and that necessary operational procedures (like travel) are streamlined and made more attractive, it should be possible to carry on the activities and achieve the advances highlighted below:

Year	Activities and Advances
1985/87	1. Start up construction, assemble equipment, organize programs, move CPIP headquarters to Sarlahi by the end of 1987.
	2. Identify promising new strains of chickpea, cowpea, pigeonpea and greengram for the Tarai and low hills/valleys.
	3. Carry out selected sector collecting of indigeneous pulses.
	4. Develop and refine management practices for existing improved strains of soybeans (Harder and Hill), mungbean (Pusa Baisakhi), blackgram (Kalu), lentils (Sindoor, Shishir and Simrick) and chickpea (Dhanush and Trishul).

5. Develop effective pesticide controls for pod borers, hairy caterpillars, thrips, and aphids and experiment on more effective, improved pesticide delivery systems (eg. electrically charged "micro-dyne").

1987/1990 1. Initiate and carry out systematic collecting of indigenous legume germplasm in collaboration with IBPGR, ICRISAT and ICARDA; concurrently increase the introduction, evaluation and testing of genetic materials from the IARC's and other countries - especially India, Pakistan and Bangladesh.

2. Select and test widely the promising new strains of major species; release superior new varieties of chickpea, lentils, soybean, mungbean, cowpea, and pigeon pea; expand testing of new crops especially Phaseolus beans and broadbeans in the hills and sweet lupins in the highlands.

3. Complete an initial survey on the present importance and future potential for the major species - especially for grasspea and horsegram (with IDRC).

4. Expand management trials on new releases; and further refine cultural practices on current varieties giving particular emphasis to their roles in local cropping systems.

5. Improve plant protection methods by combining the judicious use of pesticides (especially less toxic formulations) with insect mitigating cultural practices and cropping systems.

6. Develop combined seed treatment controls for seedling diseases and insect pests like root rots, wilt, rust, cutworm, aphids and beetles.

7. Collect, introduce, isolate, and increase best Rhiozobial strains for all major legume species, and distribute to researchers, extensionists, and farmers on suitable, efficient carriers. Encourage development of an inoculum production enterprise - either privately or parastatally operated, but separate from multi-commodity organizations.

8. Pulse extension specialist will have organized the first phase of training for ADO's and seed production specialists in major pulse growing districts.

9. Training goals for the Seventh Five-Year Plan are reached or in progress: 5 PhD's, 6 MSc's 43 m/m of group training; and 30 m/m of in-service training.

1990/93 1. Evaluate indigenous collections, mainly with graduate students (theses problems); and utilize the best of these genetic stocks in extensive recommendation with other elite materials aiming at intensifying pest resistance, general stress tolerance, and stability of production.

2. Develop cropping systems roles for some of the improved forms of pulses. For example, short duration, semi-dwarf pigeon peas (ICRISAT); early cowpeas and tropical soybeans (IITA); and adapted, large-seeded chickpeas and lentils.

3. Increase seeds of improved varieties of major pulses including selections of Phaseolus beans, grasspea and horsegram for distribution to farmers (mainly as minikits and FFT's) and to seed producing agencies.

4. Continue refining cultural practices for different growing conditions with special emphasis on elite new strains and varieties; also release more efficient Rhizobia for major legumes, and begin testing improved inoculums for secondary species (grasspea, horsegram, cowpea, Phaseolus beans).

5. Expand investigation on energy-efficient and soil conserving minimal tillage practices associated with alley-cropping and green manuring and made possible by the use of new, more effective and economic, general and selective herbicides.

6. Develop methodologies for screening pulses for product qualities - for both acceptability/palatability and cooking/baking. Perhaps most important would be screening for cooking time to reduce fuel consumption. Also, begin analysing proximate principles in released varieties, advanced breeding lines, and diverse basic germplasm. (Biochemist).

7. Shift emphasis in plant protection toward integrated pest management in which alleviating cultural practices, natural predators/parasites, and the strategic use of less noxious chemical pesticides are optimally combined.

8. Design simple inexpensive methods of crop drying using solar energy and adiabatic air movement.

Also, test simple, pest-proof, grain stores for local construction using readily available materials and ferro-cement .

9. Expand training/indoctrination of district extensionists; aggresively propagandize the benefits of legume production with new technologies; and document producer success stories.

10. Socio-economic analysis and study will be carried out on all new technologies to assess their impact on production, and to predict further needs as per achieved by farmers and consumers.

11. Select young scientists and technicians for training as per schedule: 3 PhD's, 4 MSc's, 35 m/m of group training, and 60 m/m of in-service training.

1993/96

1. Release the first nationally-developed, multiple disease resistant strains of chickpea, lentils, green gram, blackgram and soybean; and advanced selections of cowpea, pigeonpea, phaseolus bean, grasspea, and horsegram.

2. Formulate optimal management practices packages utilizing the best improved varieties for the Tarai, mid hills/valleys, and highlands for the three major moisture zones (West, Central and Eastern), and for irrigated conditions. These should be provided with the latest, most efficient Rhizobial strains, to maximize production capacity.

3. Divert increasing attention to weed management - a first order yield reducing factor and the farmer's major labor sink - through better under-

standing of how and why weeds occur, weed-minimizing cropping systems, and strategic use of efficient general and selective herbicides.

4. Test and adapt simple, powered tillers and ox-drawn equipment for more efficient primary tillage and inter cultivation; refine minimal tillage systems based on advanced general and selective herbicides; and test simple, powered threshers (IRRI type and others) for grain legumes.

5. Offer efficient and economic plant protection measures for those intractable pests when host plant resistance is not feasible, like phytophagous insects (e.g. hairy caterpillar, pod borers, aphids) and genetically unstable diseases (especially powdery mildew, rust, Cercospora, and complex seedling diseases).

6. Provide recommendations on optimal seed production practices, including plant protection for all new varietal releases of both major and secondary species; and on the best seed producing environments in Nepal for the different species.

7. Carry out biochemical studies in support of research on pulse nutritional values, plant growth processes as affected by disease environmental conditions, and plant nutrient requirements as derived from both organic and inorganic sources. An ongoing project will analyze key nutritional factors in the basic germplasm as well as in advanced breeding lines.

8. Establish a regular schedule for indoctrinating and training of extension/production specialists;

and publicize the new pulse production packages whenever possible through releases to the press, radio spots, and bulletins /leaflets.

9. Meet training targets - approximately 3 PhD's, 3 MSc's, 35 m/m group training, and 60 m/m in-service training. However, some flexibility in these schedules is desirable to allow training of staff when they are 'ready' and as mutually convenient both for the trainee and the program.

1996/2000 1. Develop and release high-yielding, multiple-pest-resistant, and stress tolerant varieties of all major grain legumes; and partially resistant/tolerant strains of the secondary species. Also, greatly intensify varietal improvement in emerging secondary species, like Phaseolus beans, cowpeas, guar, broadbeans, and possibly sweet lupins (for higher elevations). This list may also include grasspea and horsegram if followup agro-economic surveys provide justification.

2. Formulate optimal production packages including plant protection for the improved varieties of all major pulse species in the six important growing regions; and continue refining packages for elite strains in the secondary species. These formulations should include viable sources of the best Rhizobial inoculums.

3. Recommend more efficient, less onerous, appropriate mechanization of production methods aimed at increasing farmer output, intensifying cropping, improving product quality, and generally making the farmer's lot more attractive.

4. Develop optimal pest management practices fully integrated into the most important cropping systems and focussed on the more intractable pest problems not amenable to solution through host plant resistance. These methods should be applicable to both the major and secondary grain legumes by the turn of the century.

5. Create a national awareness of the important role of grain legumes in human diet and of the many advantages of including legumes in the farming system using recommended management practices and improved varieties.

6. Encourage professional seed growers to specialize on pulses in close collaboration with researchers and extensionists; and foster a new small industry - producing improved strains of Rhizobial inoculants for all major and secondary legumes.

7. Assess the impact of improved technologies for legume production through socio-economic studies and farmer surveys. These studies should provide considerable information on farmer practices, needs, and motivations for future work.

8. Complete training targets for Phase II, totalling 9 PhD's, 10 MSc's, 105 m/m of group training, and 170 m/m of in-service training. Although training is ongoing and indefinite, the CPIP should, by the year 2000, be a highly effective, close knit team of professional pulse researchers.

Predicting the potential effects of research and technology advances is difficult at best as many factors are involved. Moreover, conditions and needs change for a number of reason sometimes negating the potential of otherwise sound advances. Plant pests are particularly difficult to predict - as old disease and insect problems are solved existing forms tend to mutate or totally new pests may appear.

On the other hand, unexpected breakthroughs are likely to occur that tend to feed on themselves and lead to new directions in development. Among the most interesting such improvements are radically new forms of existing crops that find new roles in the farming system or cause new cropping patterns and uses to develop. These new 'forms' may evolve as earlier maturities, tolerance of previously limiting physical stresses (e.g. drouth, waterlogging, pH or temperature extremes), multiple pest resistance, and/or improved product quality or uses. Therefore, pulse researchers, in collaboration with their farming systems colleagues, should be constantly vigilant for any such innovative possibilities arising from new component technologies.

IMPACT ON PRODUCTION

Research will have an ever increasing impact on national pulse production for the forseeable future assuming a well-coordinated, effectively-functioning, adequately-supported team effort by trained researchers. It is even possible to broadly estimate the separate components of expected progress as illustrated below:

Period		Advances	Impact (Percent)
1985/87	1.	Increased seed production of improved strains of soybean, lentils, chickpea, mungbean and blackgram	1
	2.	Adoption of improved management practices	1
	3.	Production of better pest control methods	1
			ST = 3%
1987/90	1.	Further spreading of improved varieties of major legumes	3
	2.	Continued improvement in management adopted by farmers	5
	3.	Better pest control	2
			ST= 10%
1990/93	1.	Release of the second round of new varieties of major legumes plus cowpea, pigeonpea, Phaseolus bean and fieldpea	5
	2.	Further improvement in management practices with particular reference to cropping systems	4
	3.	Dissemination of improved strains of Rhizobium	3
	4.	More rational and effective use of pesticides both as foliar sprays and seed treatment	3
			ST = 15%

Year		Advances	Impact (Percent)
1993/96	1.	Release of new, improved varieties (3rd. round); and new forms of existing species (eg. pigeonpea, cowpea, chickpea, green gram)	12
	2.	Modifications in management package for new varieties and forms adopted by farmers	5
	3.	Adoption of integrated pest management with IRG/M involvement at the community level	4
	4.	More efficient farm operations such as appropriate mechanization, use of herbicides, and solar drying	2
			ST = 23%
1996/2000	1.	Further spread of new 3rd round pest-resistant varieties; and release of 4th round improved strains of major species	17
	2.	Spread of 2nd and 3rd. round secondary species including new strains of grasspea and horsegram	9
	3.	Wide-scale adoption of recommended management practices including latest advances in Rhizobium	4
	4.	Universal adoption of economic plant protection packages characterized by alleviating cultural practices, seed treatment, and more efficient field delivery of pesticides (e.g. "microdyne")	4
	5.	Increase from adoption of appropriate mechanization	2
			ST = 36%

Productivities

These improvements are likely to increase productivities (on the same land area) in a stepwise ('punctuated equilibrium') fashion - e.g. every 2 to 4 years; and cumulatively, that is above the previous base. The effect on national pulse productivity is calculated as shown below:

PRODUCTION ESTIMATES

Year Year	Without Technology ('000 Tons)	With Technology Cumulative (%)	With Technology Tons ('000)	Increase Over Prior Yr.	Increase Over W/O Tech.
1984/85	94	-	-	0	
1985/86	94	0	94.0	0	0
1986/87	94	3	96.8	2.8	2.8
1987/88	94	3	99.7	2.9	5.7
1988/89	94	3	102.7	3.0	8.7
1989/90	94	4	106.8	4.1	12.8
1990/91	94	4	111.1	4.3	17.1
1991/92	94	5	116.6	5.5	22.6
1992/93	94	6	123.7	7.1	29.7
1993/94	94	7	132.3	8.6	38.3
1994/95	94	8	142.9	10.6	48.9
1995/96	94	8	154.3	11.4	60.3
1996/97	94	8	166.7	12.4	72.7
1997/98	94	9	181.7	15.0	87.7
1998/99	94	9	198.1	17.4	104.1
1999/2000	94	10	217.9	19.8	123.9
Total: 1985/86 to 2000	1,410	=	2,045.3	=	635.3

This projection shows the multiplier effect of cumulative increases. It also illustrates how the payoff from research increases with time as the program develops. Thus, the accrued increase from research is expected to be less during the early years of program development compared with return expected in Phase II as shown below:

Period	Increase ('000 Tons)	Market Value (Rs. Crores)
- Seventh Five-Year Plan : 1985/90	30.0	24
- Eighth Five-Year Plan: 1990/95	156.6	125
- Ninth Five-Year Plan: 1995/2000	448.7	359
Total 15 years =	635.3	508

Program Costs in Perspective.

Despite the more modest returns expected during Phase I the entire cost of the program (Rs.324.4 lakhs) would amount to only 13.5 percent of the increased production (on the same land area) during that period. Expressed in other terms, the projected total costs of both Phase I and II (Rs.771.5 lakhs) would amount to only 1.5 percent of the expected increase in production during the next 15 years as the direct effect of pulses research.

Success in research is equally likely to affect the total land area (including cropping intensification) planted to pulses as a consequence of the enhanced attractiveness of growing these crops. This indirect effect if calculated conservatively at a cumulative 2 percent per yr. for 14 years (1986/87 to 2000) would increase total production to 387,600 tons from 295,300 ha for an average yield of 9.74 q/ha. This represents a total production increase in tonnage of 306 percent, land area of 132 percent, and mean yields of 232 percent from the present to the end of this century.

Impact on Human Nutrition

Implications of pulse research for human nutrition are even more impressive than for production. If total in-country production of pulses were alloted equally to every man, woman and child, the present availability is calculated as 5.7 kgs. per year. This figure rises to 9.2 kg. per annum (assuming the same land area) by the year 2000 or an increase of 61 percent over the 15 year period. Reduced to daily consumption this means 25.2 g. of pulses containing 6.29 g. of plant proteins plus about 90 calories and some important minerals and vitamins. This represents only about 15 percent of daily protein and 4.5 percent of energy requirements.

If, realistically, total land area devoted to pulses increases at the cumulative rate of two percent per year, production would reach 257,600 tons by the year 2000. This means a total availability of 12.2 kg/caput or 33.4 g/day (8.4 g/ protein and 117 k. cal) per inhabitant. This is equivalent to above 21 percent of daily protein requirements and 5.3 percent of energy needs. Considering targets for increased cereals production (190 kg/caput) and animal protein intake (11.25 g/day) total protein intake would be a well balanced 6/g/day/person availability by the end of the century.

APPENDIX 1

RECENT PRODUCTION OF PULSES IN NEPAL

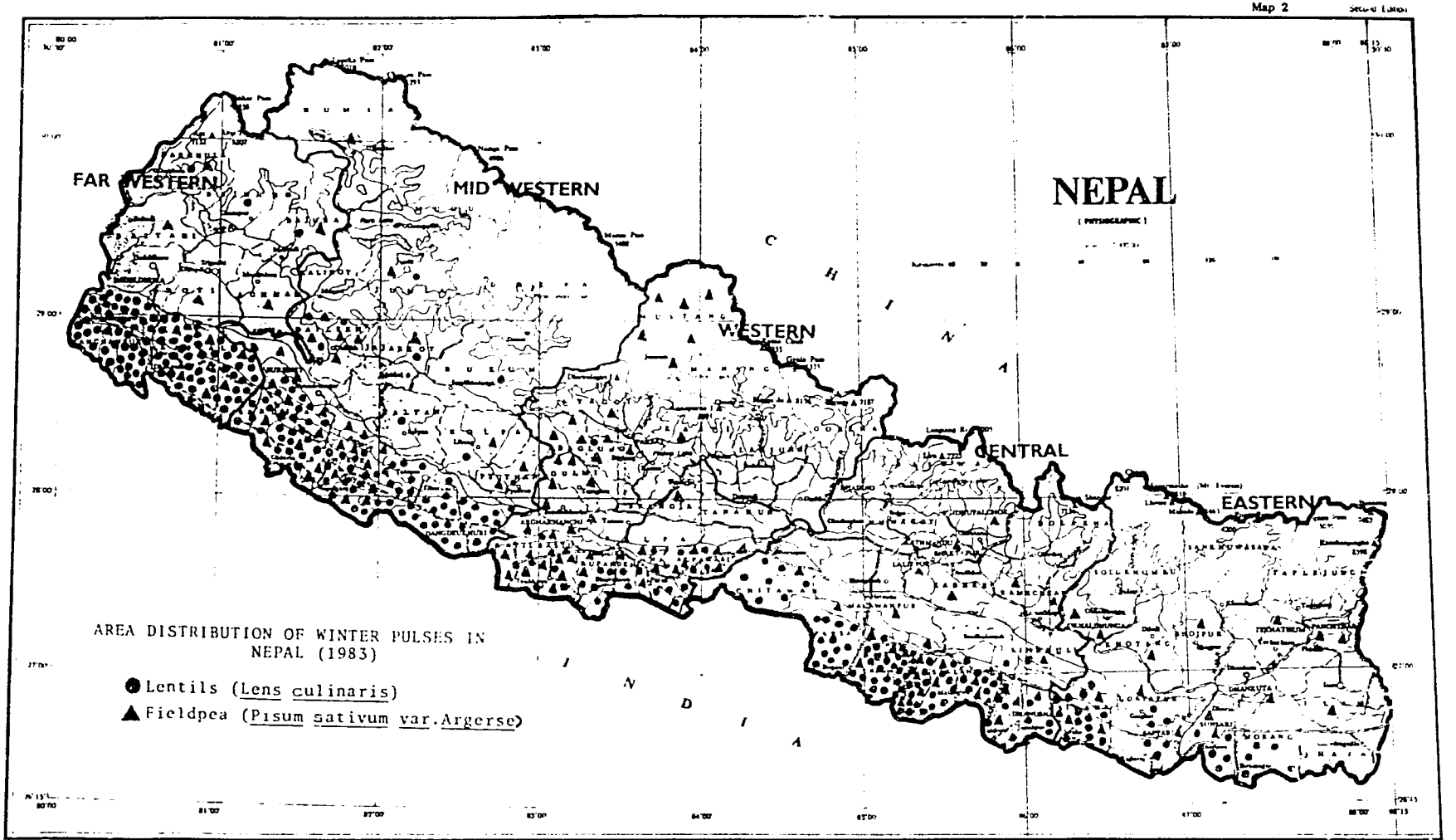
1984/85 ESTIMATES (Hectares)

CROP	TARAI	MID HILLS	HIGH HILLS	TOTAL
Lentils	42,780	1,708	152	44,640
Chickpea	33,991	350	16	34,357
Grasspea	48,632	621	-	49,253
Fieldpea	8,357	2,323	565	11,245
Soybean	1,918	14,866	1,650	18,434
Blackgram	7,683	7,327	1,176	16,186
Horsegram	11,755	6,507	2,461	20,723
Pigeonpea	12,442	242	12	12,696
Mungbean/ Others	1,517	4,160	239	5,916
Total	169,075	38,104	6,271	213,450

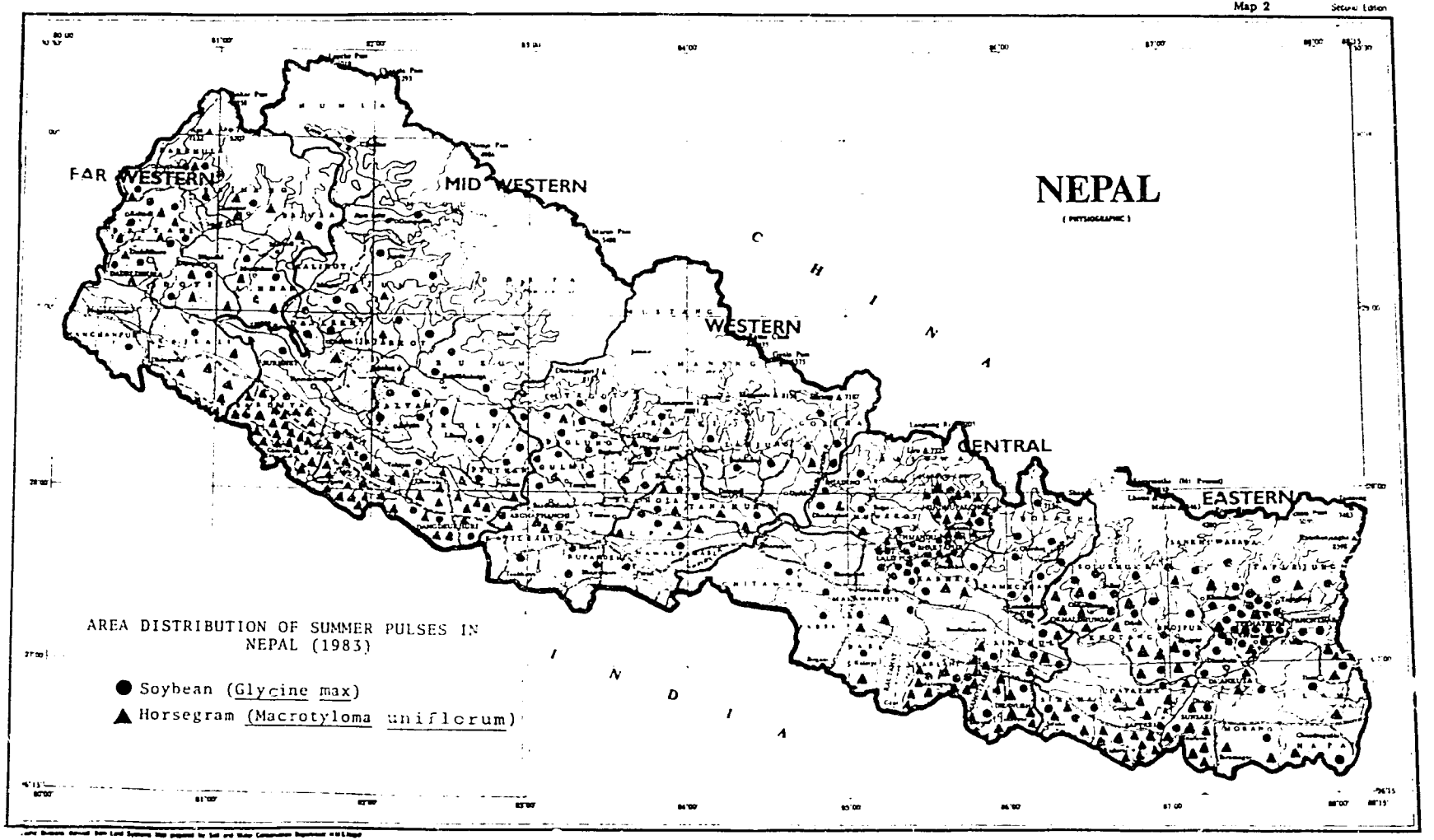
APPENDIX 2

Map 2
FAR WESTERN
MID WESTERN
WESTERN
CENTRAL
EASTERN
NEPAL
C H I N A
I N D I A
AREA DISTRIBUTION OF WINTER PULSES IN NEPAL (1983)
Chickpea (Cicer arietinum)
Grasspea (Lathyrus sativus)

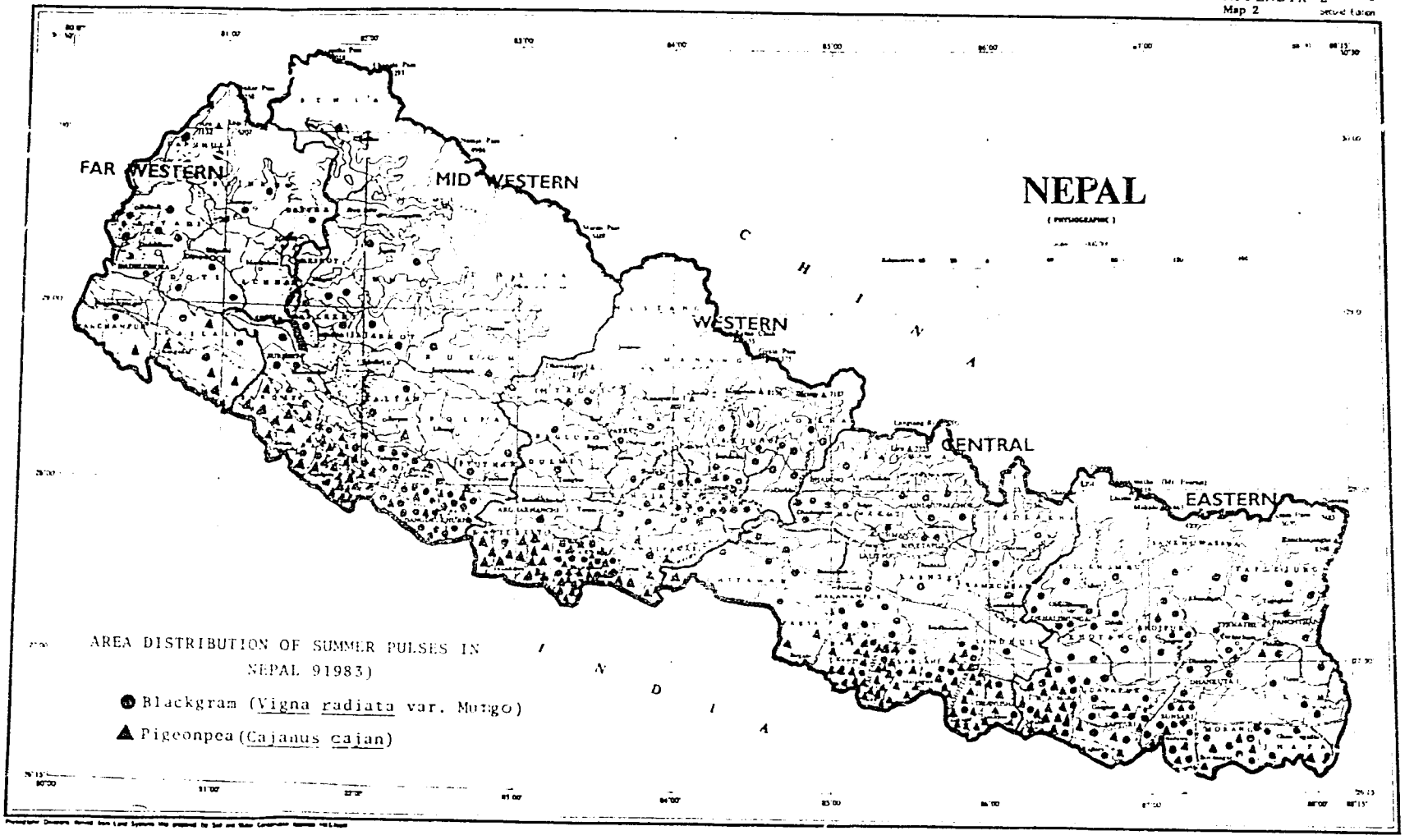
Map 2


FAR WESTERN
MID WESTERN
WESTERN
CENTRAL
EASTERN
NEPAL
C H I N A
I N D I A
AREA DISTRIBUTION OF WINTER PULSES IN NEPAL (1983)
Lentils (Lens culinaris)
Fieldpea (Pisum sativum var. Argerse)

Map 2


NEPAL
(PHYSIOGRAPHIC)
FAR WESTERN
MID WESTERN
WESTERN
CENTRAL
EASTERN
C H I N A
I N D I A
AREA DISTRIBUTION OF SUMMER PULSES IN NEPAL (1983)
Soybean (Glycine max)
Horsegram (Macrotyloma uniflorum)

Map 2 Second Edition



APPENDIX 3

REPRESENTATIVE CROPPING SYSTEMS IN LEADING GRAIN LEGUMES PRODUCING REGIONS (BHARATI, 1980)

Name of Legume Crop	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Remarks 1/
(1) Name of Region: Tarai																									
Mungbean	Wheat			Mungbean				Rice				Wheat				Mungbean			Rice				Wheat		
Chickpea	Chickpea				Early paddy				Late paddy		Relay chickpea								Paddy				Relay		
Lentil	Lentil				Early paddy				Late paddy		Relay lentil								Paddy				Lentil		
Lathyrus	Lathyrus				Early paddy				Late paddy		Relay lathrus								Paddy				Lathyrus		
Pigeonpea	Wheat or winter legumes						Pigeonpea in paddy bunds					Wheat							Pigeonpea in paddy bunds						
(2) Name of Region: Inner Tarai																									
Mung bean	Wheat			Mung bean				Rice				Maize				Mung bean			Rice					Wheat	
Chickpea	Chickpea						Rice				Chickpea & Mustard					Maize						Chickpea			
Lentil	Lentil						Rice				Lentil & Mustard					Maize						Chickpea			
Lathyrus	Lathyrus						Rice				Lathyrus & Mustard & lenril							Finger millet					Lathyrus		
Pigeonpea	Wheat or winter legumes						Rice + Pigeonpea in bunds						Wheat							Pigeonpea					
(3) Name of Region: Mid hills																									
Soybean	Wheat						Rice + Soybean in bunds					Barley				Maize + Soybean							Wheat		
Blackgram	Wheat						Rice + Blackgram in bunds					Barley							Blackgram				Wheat		
Horsegram	Wheat						Rice + Horsegram in bunds					Barley				Maize + Horsegram							Wheat		
Rice bean	Wheat						Rice + Rice bean in bunds					Barley				Maize + Rice bean							Wheat		
Peas	Peas						Rice					Barley						Maize			Pea + Mustard				

1/ Indicate types of soil and land classification (where applicable), e.g., paddies ("sawah" or irrigated lowland normally planted to rice) or upland.

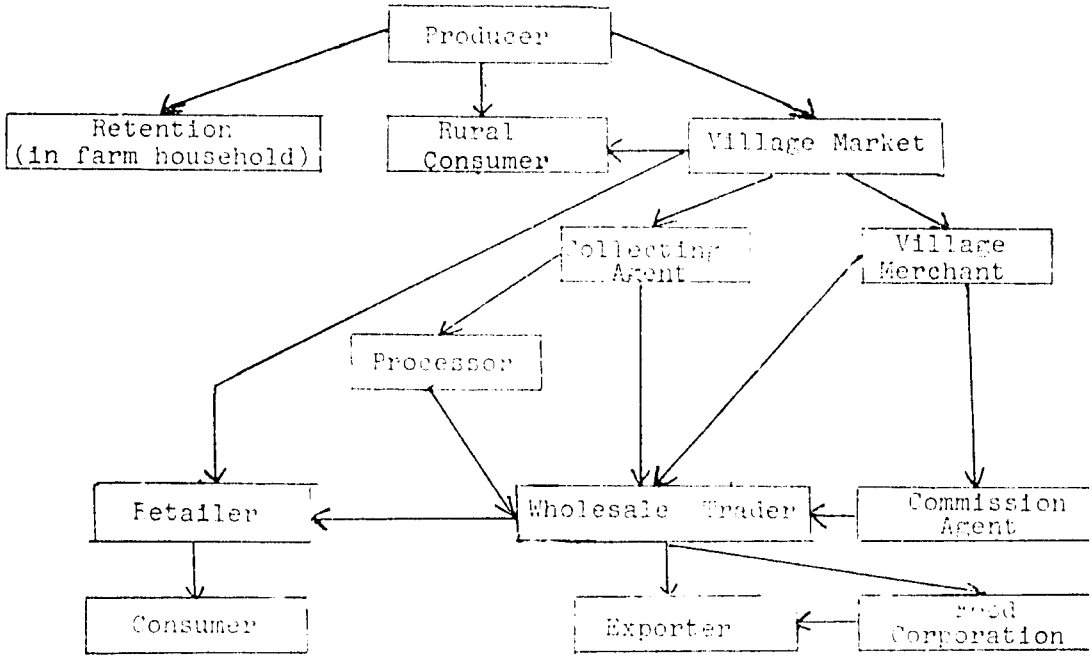
2/ Dotted lines signify intercropping.

3/ Mixed cropping.

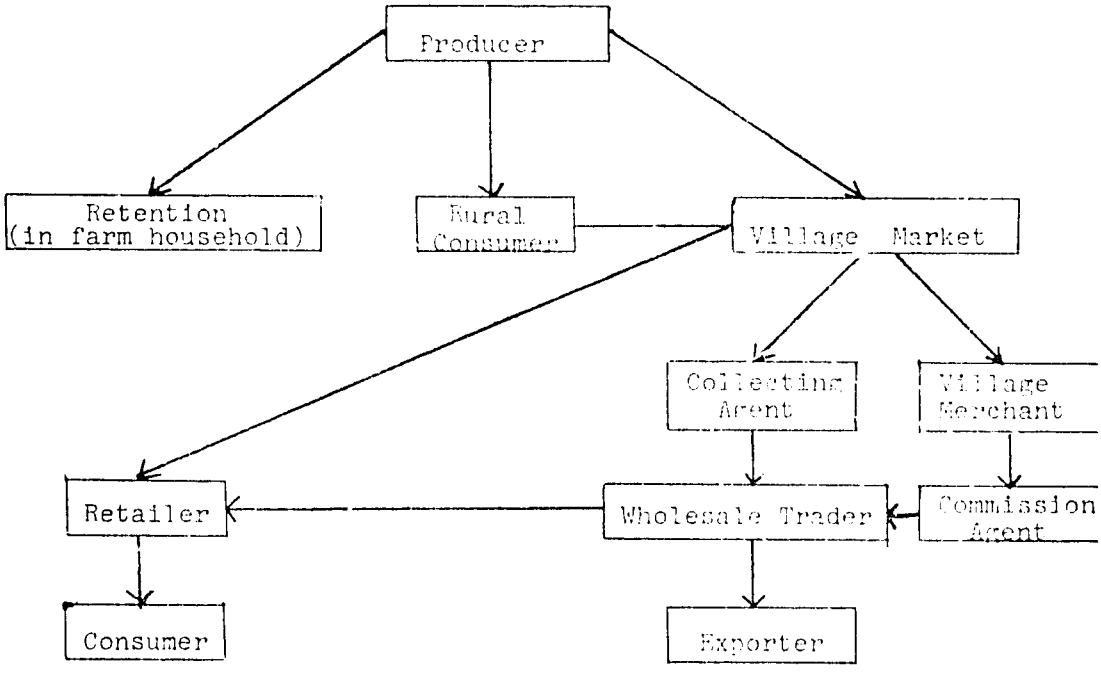
APPENDIX 4

Flow Chart for Marketing Channels (Bharati, 1980)

(1) Lentil



(2) Other Grain Legumes



Appendix - 5

A GENERAL DESCRIPTION OF THE MAJOR CULTIVATED PULSES AND SOME SECONDARY SPECIES WITH FUTURE POTENTIAL IN NEPAL

Winter Legumes

1. Grasspea. (*Lathyrus sativus* L.), Also known as chickling vetch and Khesari. A hardy winter crop that grows and produces well on a wide range of soils, particularly noted for good production on poor soils subject to drought. It is a much branched, straggling, suberect, annual herb with stems 60 to 90 cm. in length. The crop matures in 4 to 6 months and yields may range up to 1000 to 1500 kg/ha. The plant makes a good cool weather forage, while the leaves can be eaten as a pot herb, and the seeds used as a pulse. The major drawback is that heavy consumption of the pulse over several weeks causes a serious neurological disease in both humans and animals called 'lathyrism'.

2. Lentil (*Lens culinaris* Medik). Other names are masur-dhal, tillseed. A small annual bushy herb, 20 to 75 cm. tall, softly hairy, slender stems, with compound-pinnate leaves and small leaflets. There are two major types - the small-seeded types (ssp. *microsperma* Baumb.) and the large-seeded forms (ssp. *macrosperma* Baumb.) Seed size ranges from about 2 g/100 seeds in the small-seeded types up to 8 g/100 seeds in the large-seeded types. The lentil is considered one of the most nutritious of pulses and is used whole or split for dhal or soups, or as flour mixed with cereals in a wide range of dishes. Young pods are also used as a vegetable; and the vegetative portions, husks and bran are fed to livestock. Often planted after rice or maize.

3. Chickpea (Cicer arietinum L.) Other names are Bengalgram or garbanzo. An annual herb, erect or spreading, much branched, 20 to 100 cm. tall; pubescent, dark green to bluish in color; leaves are glandular pinnate with small, ovate to elliptic leaflets though sometimes larger. Grown usually as a rainfed, cold weather crop or in dry climates or well-drained soils in association with mustard or wheat; matures in 3 to 7 months with normal yields of 400 to 1600 kg/ha of dry seeds, though yields exceeding 3000 kg/ha have been recorded. It is used mainly as a dry pulse in dhal and numerous other dishes, but young plants and green pods may be eaten like spinach. The seeds, husks and foliage are also fed to animals.

4. Fieldpea. (Pisum sativum L., var. arvense L., syn Pisum arvense L.). Other names: gardenpea, matar. An erect to semi-procumbent, sometimes twining succulent, cool weather, annual herb; from 80 to 200 + cm. tall (or vine length). Grown mainly in northern India and Nepal both in association with winter crops like wheat or mustard and as a monocrop. The tender green pods and seeds are a favored vegetable, while the dried seeds may be used as a pulse or dhal and the vegetative portions are fed to animals. Sometimes grown mixed with oats for fodder.

5. Broadbean. (Vicia faba L.). Other names: horsebean, faba bean, Windsorbean, tickbean. A robust, upright-growing annual herb; stems large, unbranched; leaves large, compound with large oval leaflets; large pods-3 to 4 seeds/pod; two seed types: large seeded type-var. major = 110 g/100 seeds; small-seeded type-var. equina = 66 g/100 seeds. Yields can be very high: 3000 to 6000 kg/ha. Large seeded types often used as a vegetable; pulse is frequently roasted like peanuts, otherwise ground or cooked in various prepa-

rations. Sometimes used as a green maure or stockfeed. Major deterrent is the possibility of causing 'favism' - a severe hemolytic anemia in certain Mediterranean people with an inherited enzymatic deficiency.

Summer Legumes:

1. Horsegram. (Macrotyloma uniflorum Verdc., syn. Dolichos biflorus auct.). Other names : Madras gram, Wulamula. Low growing, slender, suberect, annual herb, with downy stems and branches 30 - 50 cm. tall; leaves trifoliolate; pods 3 - 5 cm. with 5 - 7 seeds. Crop matures in 4 - 6 months for seed and 6 weeks for forage; yields average 130 - 300 kg /ha but sometimes up to 990 kg /ha ; green forage up to 5 - 12 t/ha. often cultivated as a 'poor' man's pulse in India. Seeds are parched, boiled or fried, then eaten whole or ground. Seeds may be fed to horses (boiled); and vegetative portion used as fodder.

2. Soybean. (Glycine max. Merr.). Robust-growing annual herb, both erect and semi-twining forms occur ranging from 35 to 200 cm in height ; matures in 75 to 200 days; foliage dark green, lightly pubescent; pods numerous, clustered at nodes, contain 2 - 3 seeds; grown mainly as a summer crop in temperate and sub-tropical regions, but increasingly grown in low moist tropics. It withstands water logging better than most pulses. Seeds large (20 to 40 g/100), rich in protein (33 to 40 percent), and moderate in oil content (± 20%). Major source of industrial proteins for both humans and animals, and as a source of vegetables oils. Seeds not very palatable when eaten as a pulse; but is highly palatable when processed or used in traditional oriental dishes like 'tempe' and 'tofu'. Deterrents to production in torrid zones are rapid loss of seed viability and susceptibility to shattering.

3. Mungbean/Blackgram (*Vigna radiata* var. *aureus* Verdc. and *V. radiata* var. *mungo* Verdc.). Other names for mungbean are: green and golden gram; and for blackgram: Urad, mash, wooly pyrol. Mungbean has spreading or reflexed pods with short hairs; while blackgram has erect, long-haired pods, larger seeds (black) with a concave hilum. It is an erect to suberect, pubescent, annual herb. The duration is usually short from 60 to 120 days with average yields ranging from 400 to 1500 kg/ha. Usually grown on well-tilled loams or clayey soils, often following or preceding rice. The major use is a pulse split and cooked or sprouted (highly regarded for sprouts); but the green pods are sometimes cooked and the vegetative portions are used for fodder. Both mungbean and blackgram are reputed to be more easily digested than many other legumes and used as special foods for convalescents and children.

4. Pigeonpea. (*Cajanus cajan* Millsp.). Other names: redgram, arhar, tur, congobean, gandul. Semi-woody, short-lived perennial shrub 100 to 500 cm. tall. Highly drouth tolerant once established on account of its well-developed root system. Primarily a warm weather species, but tolerates mild winters and commences growing quickly as soon as the temperatures rise. Branching may be simple or complex, spreading or upright in different types; leaves are trifoliolate with varying sizes of lanceolate leaflets. Pods may be solid green or purple or mottled carrying 2 - 8 seeds. Seeds are globular in shape and vary from about 7 - 15 g /100. Yields generally good, 700 to 1500 kg/ha, sometimes 2500 kg/ha. The primary use is as a dhal (predominant in India); but green seeds, especially large-seed types, make an excellent vegetable; the plant may also be used for cover, fodder, and pasture. In Nepal it is often planted with maize, maturing in the spring.

5. Cowpea. (*Vigna unguiculata* Walp.). Other names: southern pea, blackeye pea, lubia, niebe, or coupé. A hot-weather crop of both the tropics and sub-temperate regions; short duration (60 - 100 days), frequently mixed with other crops like maize and millet. An annual, erect, procumbent or twining herb tolerant of high temperatures and drouth. Leaves are trifoliolate with relatively large ovate or lanceolate/haustate leaflets. Pods are generally long, often with 8 - 10 or more seeds ranging from about 8 to 20+g/100. A wide range of seed colors are encountered, but most consumers prefer light colored seeds with easily removed, rough or wrinkled testas. A special variant of cowpea, var. *sesquipedalis* has exceptionally long stringless pods and is used as a vegetable. The cowpea is unique in being relished for its tender green leaves, pods and seeds as a pot herb; as a multi-purpose pulse; and for fodder. The mature seeds are particularly nutritious and low in both metabolic inhibitors and the flatulence factor.

Promising Secondary Species

Several other grain legume species could be successfully grown in Nepal but have not yet been tried nor grown extensively. Some of these bear mention as possibilities for future development if conditions are favorable. Some have interesting export potential if given some minimal attention for development. They include:

1. Cluster bean or guar (*Cyamopsis tetragonolobus* L. Taub.)

A hot weather crop. Immature pods used as a vegetable; green plants are fed to cattle; and guar gum is processed from the seeds and extensively used in making paper, textiles, foods, cosmetics, pharmaceuticals, mining and petroleum industries.

2. Hyacinth bean (Lablab niger Medik.). Grown extensively throughout India where the young pods and tender green beans are used as a vegetable, and the dry seeds as a pulse. It is also used as a fodder and grown for cover, green manure, and animal feed.

3. Field or common bean (Phaseolus vulgaris L.). Other names: dry, dwarf, kidney, French, navy, snap, runner, and string bean. This is the most extensively cultivated and consumed pulse/vegetable in the world. It is a 'cool' or moderate summer crop widely adapted to both temperate and tropical conditions. Some cut or string beans are already grown in Nepal; but there should be good prospects for both production/local consumption and export to Europe (and elsewhere) as a pulse.

4. Lima bean (Phaseolus lunatus L.). Similar to the dry bean, but more widely adapted, higher yielding and less susceptible to pests. Lima beans are used both as a vegetable (green beans) and as a pulse but are not nearly as popular as the common or dry bean.

5. Rice bean (Vigna umbellata (Thunb.). Ohwi and Ohashi). A summer crop cultivated as a dried pulse in India and south-eastern Asia. The beans are sometimes cooked with or instead of rice; and the green leaves or pods may be used as a pot herb. It performs better than some legumes under humid conditions, but is also moderately drouth tolerant and less susceptible to some of the diseases and pests that plague other pulses.

6. Adzuki bean (Vigna angularis (Willd). Ohwi and Ohashi). This annual herb is native to eastern Asia being grown both for its edible green pods and as a pulse. There should be a good export market for this bean to Japan and its neighbors.

Appendix 6

Ecosystematic Attributes of Legumes (after Duke, 1978)

Appendix 6-1

Scientific name	Precipitation (dm)				Temperature (°C)				pH			
	Min.	Mean	Max.	(No.)	Min.	Mean	Max.	(No.)	Min.	Mean	Max.	(No.)
Cajanus cajan (L.) Millsp.	5.3	14.5	40.3	(60)	15.8	24.4	27.8	(60)	4.5	6.4	8.4	(44)
Cicer arietinum L.	2.8	6.7	15.0	(41)	6.3	17.0	27.5	(41)	5.0	7.2	8.3	(35)
Cyamopsis tetragonoloba (L.) Taubert	3.8	7.5	24.1	(16)	7.8	22.0	27.5	(16)	5.3	7.2	8.3	(14)
Glycine max (L.) Merr.	3.1	12.8	41.0	(108)	5.9	18.2	27.8	(108)	4.3	6.2	8.4	(98)
Lablab purpureus (L.) Sweet	7.0	14.5	40.3	(16)	14.5	21.9	27.5	(16)	5.0	6.2	7.5	(15)
Lathyrus sativus L.	3.2	7.4	13.6	(31)	4.3	13.0	27.5	(31)	4.5	6.8	8.3	(27)
Lens culinaris Medik.	2.8	7.9	24.3	(35)	6.3	14.5	27.3	(35)	4.5	6.8	8.2	(32)
Macrotyloma uniflorum (Lam.) Verdc.	7.0	19.8	42.9	(8)	23.4	25.3	27.5	(8)	5.0	6.4	7.5	(6)
Phaseolus lunatus L.	3.1	15.5	42.9	(43)	8.7	20.4	27.5	(43)	4.5	6.2	8.4	(36)
Phaseolus vulgaris L.	0.9	12.8	42.9	(217)	5.7	19.3	28.5	(216)	4.2	6.4	8.7	(144)
Pisum sativum L.	0.9	9.2	27.8	(137)	5.0	12.9	27.5	(137)	4.2	6.3	8.3	(122)
Vicia faba L.	2.3	8.0	20.9	(95)	5.6	12.1	27.5	(95)	4.5	6.6	8.3	(87)
Vigna angularis (Willd.) Ohwi & Ohashi	5.3	12.5	17.3	(8)	7.8	17.0	27.8	(8)	5.0	6.1	7.5	(7)

Scientific name	Precipitation (dm)				Temperature (°C)				pH			
	Min.	Mean	Max.	(No.)	Min.	Mean	Max.	(no.)	Min.	Mean	Max.	(No.)
Vigna mungo (L.) Hepper	5.3	12.4	24.3	(13)	7.8	22.0	27.8	(13)	4.5	6.4	7.5	(12)
Vigna radiata (L.) Wilczek	2.8	12.5	41.0	(29)	7.8	20.9	27.8	(29)	4.3	6.6	8.1	(27)
Vigna umbellata (Thunb.) Ohwi & Ohashi	7.0	11.1	17.3	(3)	23.5	25.3	27.5	(3)	6.8	7.2	7.5	(2)
Vigna unguiculata (L.)	7.0	12.2	17.3	(8)	12.2	21.3	27.5	(8)	5.0	6.1	7.5	(7)

Appendix 7

Economic Legumes: Their Tolerances, Yields, Centers of Diversity, and Ecocenters

Common name	Scientific name	Tolerance[a]	Yield[b]	Center of diversity[c]	Ecocenter[d]
Bean, adzuki	Vigna angularis (Willd.) Ohwi & Ohashi	Dr. Fr Ht Sl Vi	1,100 sd	CJ, II	
Bean, broad	Vicia faba L.	Hi In Lo Sl Vi	6,600 sd	CE, ME, SA	0812
Bean, haricot	Phaseolus vulgaris L.	Al, Ba Di Dr He Hf Hi La Lo Mn Pe Ph Sm So Vi Wl	5,000 fr	MA, SA, CJ	1319
Bean, lablab	Lablab purpureus (L.) Sweet	Al Di Dr Ht Ps Qz Sh Vi	1,400 sd	AF	1422
Bean, lima	Phaseolus lunatus L.	An Di Dr Hi Ht La Lo Ph Sm Vi	2,500 sd	MA, SA	1620
Bean, mung	Vigna radiata (L.) Wilczek	Dr He Hi La Lo Sa Sl Vi	1,100 sd	II, CJ, HI	1221
Bean, rice	Vigna umbellata (Thunb.) Ohwi & Ohashi	Dr Sl	200 sd	HI, II, CJ	1125
Bean, yard-long	Vigna unguiculata ssp. sesquipedalis (L.) Verdc.	La Ph Ps Se Vi	10.000 fr	AF, HI	1722
Chickpea	Cicer arietinum L.	Di Dr Hi Na Ph Vi	2,000 sd	HI, CE, NE	0717
Gram, horse	Macrotyloma uniflorum (Lam.) Verdc.	Dr Ps Qz	300 sd 12,000 wm	HI	2025
Gram, black	Vigna mungo (L.) Hepper	Dr Hi Hs Lo Si Vi	800 sd	HI	1222
Guar	Cyamopsis tetragonoloba (L.) Taubert	Ba Di Dr Fu Hi Ht Hs Na Vi	2,000 sd	HI, AF	0822

Appendix 7.2

Common name	Scientific name	Tolerance[a]	Yield[b]	Center of diversity[c]	Ecocenter[d]
Lentil	Lens culinaris Medik	Ak Di Dr Fr Fu Hi Hs Ht In Na Ps Sl Vi	1,700 sd	NE	0814
Lupine, white	Lupinus albus L.	Fr Fu Hi Lo Na Ph Vi We Wl	7,500 hay 1,000 sd	Hl	0813
Pea, cow	Vigna unguiculata (L.) Walp. ssp. unguiculata	Al Dr Hi Ht La Lo Ne Ps Sh Sl Vi We Wt	2,500 sd	AF, HI	1422
Pea, garden	Pisum sativum L.	Al Di Fr Fu Hf Hi Ht La Lo Mw. Sl Sm Vi Wt	1,800 sd	NE, ME, AP	0913
Pea, grass	Lathyrus sativus L.	Dr Hi Hs Lo Ps Ru Vi Wl	1,000 sd 30,000 wm	CE, ME	0713
Pea, pigeon	Cajanus cajan (L.) Millsp.	Di Dr Fr Hi La Lo Na Ne Ph Qz Vi We Wi Wl Wt	12,800 fr	HI, AF	1423
Soybean	Glycine max (L.) Merr.	Al Ba Di Fr Fu Hf Hi Hs Ln La Li Lo My Ne Ph Pt Sm St Vi	22,000 hay 3,100 sd	CJ	1318
Urd	Vigna mungo (L.) Heeper	Dr He Hi Hs Lo Sl Vi	500 sd	II	1221

a. Source: Duke (1978).

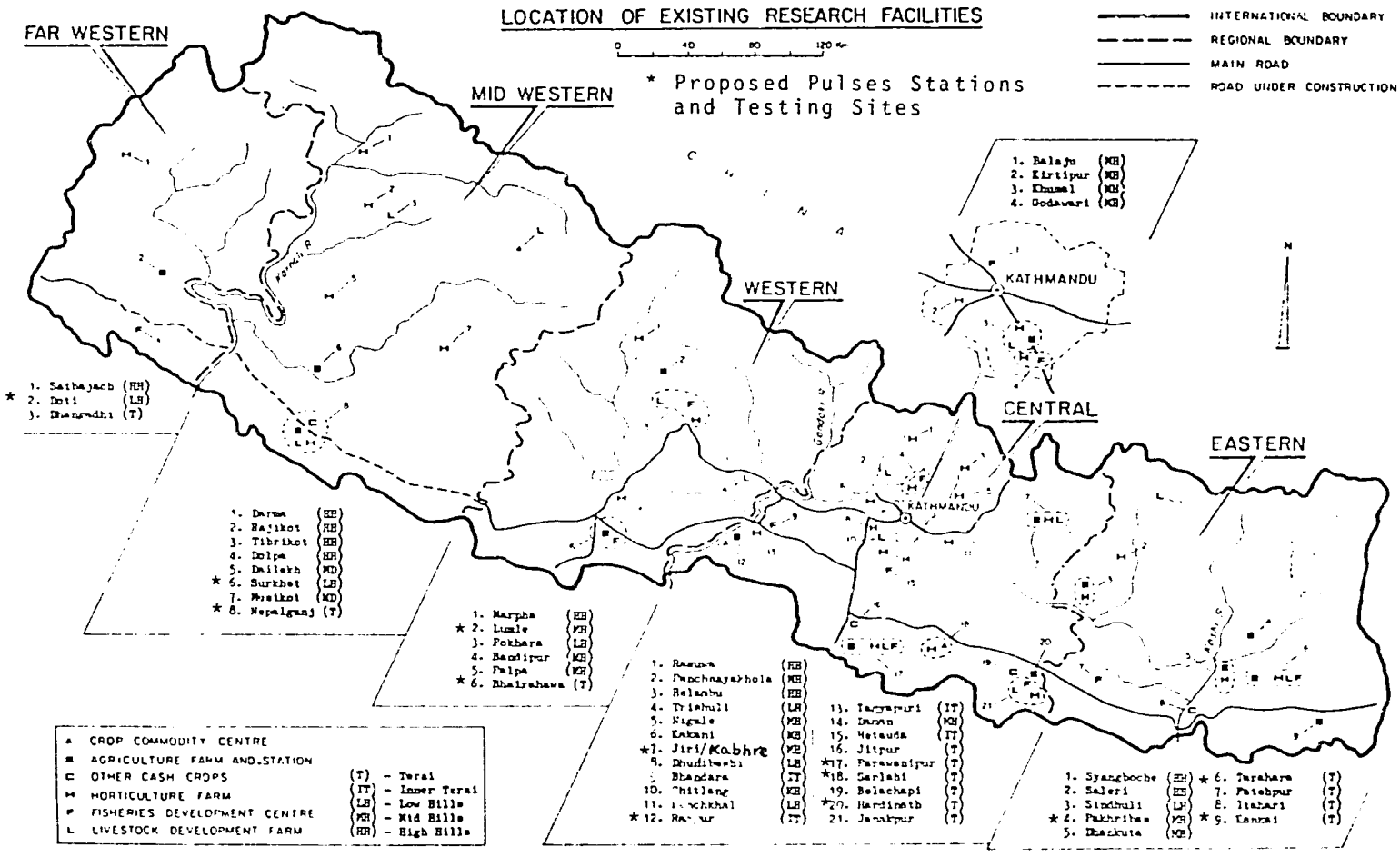
b. Tolerances: Ad, Adobe; Ak, Alkali, Al, Aluminum; An, Anthracnose; Ba, Bacteria; Bo, Boron, Bu, Bunt; Di, Disease; Dr, Drought; Fi, Fire; Fr, Frost; Fu, Fungus; Gr, Grazing; He, Herbicide; Hf, Hydrogen fluoride; Hi, High pH; Hm, Heavy metal; Hs, Heavy soil, Ht, Heat; In, Insects; La, Laterite; Li, Limestone; Lo, Low pH; Mi, Mine, Mu, Muck; Mw, Mildew; My, Mycobacteria; Na, Sodium or Salt; Ne, Nematode; Pe, Peat, Pg, Phage; Ph, Photoperiod; Ps, Poor soil; Pt, Pesticide; Qz, Sand; Ru, Rust; Se, Sewage Sludge; Sh, shade; Sl, Slope; Sm, Smog; So, So_2; St, Smut; Sv, Savanna, Uv, Ultraviolet; Vi, Virus, We, Weed, Wi, Wind; Wl, Waterlog; and Wt, Wilt. Italicized Tolerance abbreviations have been reported in a recent issue of Crop Science. (I have not throughly reviewed the journal.)

c. Yields: a number indicates the yield in kg/ha. This will be followed by lower case code letters indicating what yield is recorded. Symbols: dm, dry matter, dr, drug; fib, fiber; fl, flower; fo, fodder; fr, fruit; hay, hay, inflo, inflorescence; lf, leaf; rt, root or rhizome; sd, seed; sh, shoot; st, stem, wm, wet matter of green biomass. Where hectare yields were not available, per-plant yield is indicated by the slash symbol (/) following the item for which the yield is recorded. For example, under aceituna, I only found per-plant yields (90 kg/fr). This is recorded as follows: 90 fr/. It is not uncommon for yield data from different countries or different technologies to vary by factor of 10. I have taken the higher figures, where credible, assuming that this represents a good target yield. Obviously this table is incomplete. One reason for issuing it now is to solicit additional yield and tolerance data on these and other economic plants.

d. Centers of diversity: CJ, China-Japan; II, Indochina-Indonesia; AU, Australia; HI, Hindustani; CE, Central Asia; NE, Near East; ME, Mediterranean; AF, Africa; ES, Eurosiberian; SA, South America; MA, Middle America; and NA, North America.

e. Ecocenter is a 4-digit number, the first 2 digits representing the mean annual precipitatin

APPENDIX 8


LOCATION OF EXISTING RESEARCH FACILITIES
0 40 80 120 Km
* Proposed Pulses Stations and Testing Sites
INTERNATIONAL BOUNDARY
REGIONAL BOUNDARY
MAIN ROAD
ROAD UNDER CONSTRUCTION
FAR WESTERN
MID WESTERN
WESTERN
CENTRAL
EASTERN
KATHMANDU
1. Balaju (KH)
2. Kirtipur (KH)
3. Khumal (KH)
4. Godawari (KH)
1. Sathajach (HH)
* 2. Doti (LH)
3. Dhangadhi (T)
1. Darma (HH)
2. Rajikot (HH)
3. Tibrikot (HH)
4. Dolpa (HH)
5. Dailekh (MH)
* 6. Surkhet (LH)
7. Musikot (MH)
* 8. Nepalganj (T)
1. Marpha (HH)
* 2. Lumle (MH)
3. Pokhara (LH)
4. Bandipur (MH)
5. Palpa (MH)
* 6. Bhairahawa (T)
1. Rasuwa (HH)
2. Panchnayakhola (MH)
3. Belanbu (HH)
4. Trishuli (LH)
5. Nigale (MH)
6. Kakani (MH)
*7. Jiri/Kabhre (MH)
8. Dhuplibesi (LH)
9. Bhandara (IT)
10. Chitlang (MH)
11. Lamjung (LH)
* 12. Rampur (IT)
13. Tangapuri (IT)
14. Dumun (MH)
15. Hetauda (IT)
16. Jitpur (T)
*17. Parsawanipur (T)
*18. Sarlahi (T)
19. Belachapi (T)
*20. Hardinath (T)
21. Janakpur (T)
1. Syangboche (HH)
2. Saleri (HH)
3. Sindhuli (LH)
* 4. Pakhribas (MH)
5. Dhankuta (MH)
* 6. Tarahara (T)
7. Patebpur (T)
8. Itahari (T)
* 9. Lamai (T)
▲ CROP COMMODITY CENTRE
■ AGRICULTURE FARM AND STATION
C OTHER CASH CROPS
H HORTICULTURE FARM
F FISHERIES DEVELOPMENT CENTRE
L LIVESTOCK DEVELOPMENT FARM
(T) - Terai
(IT) - Inner Terai
(LH) - Low Hills
(MH) - Mid Hills
(HH) - High Hills

Appendix - 9

SOME SUGGESTIONS ON FORMULATING A WORKPLAN

Preparing a workplan for both short and long term program activities can be daunting, particularly with new staff, inadequate facilities, and limited background. A further complication is the large number of pulse species being considered, some of which have received little or no attention in the world community. For these reasons some thoughts on developing the technical programs are outlined for reference purposes and primarily for the benefit of pulse scientists. These are organized according to short term, or coinciding with the Seventh Five-Year Plan (Phase I), and long term, from about 1990 to 2000 (Phase II).

PHASE I

The pulses appearing to have greatest immediate potential in Nepal are the winter crops: lentils and chickpea; and the summer pulses: soybeans, blackgram, and pigeonpea. Other species likely to merit increased attention as they are studied and experience is gained are: broadbean and fieldpea (winter or higher elevations); and cowpea, mungbean, and Phaseolus bean (summer). Among these, perhaps there is greatest incentive for mounting full scale improvement efforts on lentils because of its ease of production, excellent nutritional quality, and export potential. Moreover, most of the available sources of external technology may not apply so well to Nepalese conditions as is the case for other commodities since ICARDA is located in Syria with a Mediterranean type climate.

Among the other legume species, any major efforts on grasspea and horsegram are unlikely to have much impact for several years. These two species receive very little attention from the World Community and though hardy they are relatively primitive

and have serious quality problems. In fact, India has virtually abandoned studies on grasspea on account of the danger of lathyrism.

Collecting Germplasm

This report proposes approaching IBPGR - Rome for assistance and support to systematically collect all of Nepal's indigenous grain legume species. Actual collecting may be carried out as a joint venture between two or more IARC's -e.g. ICRISAT, ICARDA and AVRDC. In negotiating such a project the pulse program should insist on retaining a portion of each collection together with a copy of the field notes obtained by the collectors. The collected samples must be preserved in long term storage in Nepal and elsewhere. Obviously, it would not be necessary to provide staff nor budget for germplasm collecting as this project would be wholly funded from external sources as a 'turnkey' operation.

The collections can be evaluated in uniform nurseries both in country and elsewhere (ICRISAT, ICARDA, IARI) by young Nepalese MSc/PhD . plant breeding candidates as thesis topics and as an excellent background for their future assignments in the Pulses Program.

Plant Improvement

The limited staff and resources proposed for pulses in the short term preclude carrying out comprehensive genetic improvement in all but 2 or 3 species. Even in the latter, maximum use should be made of externally generated diversity. Some suggested methodologies for short term improvement of the different legumes are summarized below:

1. Lentils. Two major sources of technology are removed from the Indian subcontintent, both in distances(e.g. ICARDA and USA) and agro-climatic conditions (Mediterranean and Continental/Temperate). However, India,

Pakistan, Bangladesh and Iran may have some useful genetic materials - if it is possible to obtain them. In any event , the pulses program should plan to do crossing in Nepal; and also evaluate early generation materials from ICARDA and elsewhere. As soon as possible, one of the program's senior researchers should visit ICARDA to study crossing techniques and procedures for handling segregating generations. An appropriate genetic improvement program should include the following components:

(a) Basic germplasm evaluation comprised of several hundred lines from diverse sources in single or double row plots, 3 - 5 m long.

(b) Crossing of up to about 100 recombinations a year, at the outset, and 200 crosses after 2 - 3 years. This may be best done in pots in a screen-house for convenience, exclusion of insect pollinators and protection from pests.

(c) Early generation nurseries: about 100 to 300 plots of varying sizes depending on seeds available, generation, and other factors to be grown at two sites per year (F_2 - F_4).

(d) Advanced generations: many thousands of lines grown from single plant selections to be selected under simulated farmer's conditions.

(e) Preliminary yield tests of reasonably uniform F_4's - F_6's in small plots (2 rows) replicated 2 - 3 times. Simulate farmer's conditions (in relays or intercrops).

(f) Advanced trials: about 50 - 150 lines in 4 - 5 row plots, replicated 3 to 4 times at 4 to 5 diverse locations and cropping systems.

(g) Elite varieties trial comprised of 8 to 15 best entries grown at 10 to 20 locations including farmer's fields and simulating best farmer practices.

(h) Minikit trials/breeder's seed multiplication and outreach/extension activities: as indicated.

The objectives of lentil improvement should be to breed (or select) for:

- Adaptation and productive stability under diverse growing conditions.
- High yield, uniform maturity, large seeds, shatter resistance.
- Earliness, improved vigor, erect growth and lodging resistance.
- Disease(especially wilt) and insect pest resistance
- Good nodulation and root development.
- Tolerance to drouth and poor soil conditions.

The most appropriate and efficient breeding methods for grain legumes are mass pedigree selection (grow in bulk to about the F_4, then commence pedigree selection) and single seed descent, (carrying advancing generations as single seeds/pods per plant to about the F_4 or F_5, then selecting on a pedigree basis. However, straight pedigree selection is still recommended for the most promising materials as it allows better control and more rapid identification of elite genotypes.

2. Chickpeas. The basic procedures and methodologies outlined for lentils would apply to chickpeas; but in this case ICRISAT's program would be highly appropriate for Nepalese conditions. In fact, ICRISAT breeders will also do crossing of designated parental stocks, if so requested. Therefore, major emphasis on chickpea improvement should be to evaluate and test ICRISAT lines advancing them to uniformity (as for lentils) and deriving a testing program from elite selections. Final selecting and testing should simulate farmer's conditions, including trial grow-outs in relays and intercrops - especially with mustard. Chickpea technology should advance more rapidly than other legumes in Nepal on account of progress being made at ICRISAT, ICARDA, and India, which should be generally applicable to this country.

3. Soybeans. The technology is advancing very rapidly and good external sources of improved germ plasm are available, especially from AVRDC, IITA, and India (also Sri Lanka). Nevertheless, it may be desirable to do some breeding for specific conditions in Nepal, especially for resistance to diseases like frogeye leafspot, pod/stem blight, and Cercospora. Again, selection and testing should be done under simulated farmer's conditions such as in intercrops with maize.

4. Mungbean/blackgram. Good technology is coming out of AVRDC, India, Philippines, Indonesia and elsewhere in S.E. Asia (mainly for mungbean). Therefore, major emphasis should be given to testing and adapting this externally generated elite genetic materials. However, there is no organized international improvement

program on blackgram and it may be necessary to intensify breeding of this species along the lines suggested for lentils on account of the importance and preference for blackgram in the hills.

5. Cowpeas. Excellent, new, widely adapted varieties, especially short duration lines, are in the advanced stages of development at IITA. India is also working on this crop. Therefore, the Pulses' best strategy for the short term will be to select, test and adapt these new strains under local conditions. If cowpeas continue to gain in popularity over the next 3 to 5 years, more intensive breeding efforts may be justified.

6. Pigeon Pea. The present importance and future potential of this excellent pulse in Nepal may be underestimated, particularly since ICRISAT is making rapid strides in improving both short and long duration types for Tarai-like conditions. The recommendation on pigeonpeas is to greatly increase selection, evaluation and testing of ICRISAT-generated materials. If the crop increases in popularity for both local consumption and export, breeding efforts should be expanded accordingly. New lines should be tested both as intercrops with maize and in monocrop trials in the Tarai.

7. Fieldpea. No structural breeding or testing program is recommended until or unless this crop shows definite potential. However, local materials should be collected whenever possible (no special project or travel) and improved materials solicited from abroad. These should be grown out in small observation nurseries at 2 to 4 or more locations and small

seed lots maintained in long term storage.

8. Grasspea(Lathyrus). No specific plant improvement activities are recommended as this crop may be gradually replaced by other winter species (lentils and chickpeas). However, local germplasm should be collected whenever convenient; and new germplasm-especially lines low in ODAP (the toxin responsible for the disease 'lathyrism'). If appropriate and time permits, observation nurseries may be carried out at 2 to 5 locations.

9. Horsegram. No specific plant improvement activities at this time except to collect germplasm (when convenient), solicit new genetic stocks from India and conduct small observation trials at 2 or 3 different locations in Nepal.

10. Broadbean. Request a limited number of elite strains (e.g. up to 50 or 60) from ICARDA and other sources and conduct small observation trials in the Kathmandu Valley and at 2 or 3 sites in other agro-climatic zones. Further activities may be planned as the crop shows potential.

11. Phaseolus beans. Obtain a small trial of CIAT's elite strains (up to about 25 or 30 entries) for observation trials at 2 to 4 sites in the Hills and Valleys in summer (also at Khumaltar).

12. Other species. No special plantings are proposed at this time for other, secondary species like limabean, ricebean, adzuki bean, or clusterbean (guar) unless there are compelling reasons to do so. However, pulses researchers should remain alert to new possibilities for some of these and other exotic species to fill new niches in the cropping system, for both internal use and for export.

The real success of plant improvement efforts is best measured in terms of how readily farmers adopt the new varities. The best way to ensure the new strains are successful will be to simulate real farmer's conditions in selection and testing. For this reason legume improvers must establish close linkages and collaboration with cropping systems research. In addition, socio-economists should be closely involved in helping evaluate new varieties and their commercial potential as they near release.

Management and Plant Growth.

1. Cultural practices. The first order of priority will be to examine and verify improvements in crop management in the context of the cropping systems practiced in Nepal. Aspects to be studied and refined include land preparation, sowing times and depths, plant populations, plant nutrition (fertilizer) requirements, water management (where applicable), weed control, and harvesting methods. Special attention should be given to the implications of rapidly expanding irrigation in the Tarai and possibilities for crop intensification, especially with short duration species like cowpeas and mungbean. Experiments must relate to actual farmer's conditions and practices. That is, if the legume is grown in a particular sequence, relay, or association, cultural practices studies should simulate those systems.

2. Interactions in cropping systems. Special attention needs to be given to the mutual interactions between species in the same system. That is, various management factors applicable to each of the different component crops may be adjusted in ways designed to optimize total output; or to maximize one or another component of the system as may

be desired. Such studies are particularly important in complex relays and associations, but may also apply to cropping sequence as well.

3. Nitrogen fixation. Good nodulation of legume roots is a primary key to productivity and yield stability in these crops. Major activities for the short term would involve the importation of appropriate Rhizobium (for all grain legume species), finding effective ways of field inoculation , and increasing inoculums on suitable carriers for delivery to researchers, extensionist, and farmers. The use of legumes in cropping systems should be seen as a means of conserving chemical fertilizers and studied accordingly.

Management and growth researchers must be directly concerned with practical applications and whether Nepalese farmers will benefit from new technologies. Their chances for success will be greatly improved if they collaborate closely with national cropping systems teams and include socio-economists both in planning and evaluation. Their investigations should concentrate primarily on those species receiving greatest attention in breeding: lentils, chickpeas, soybean, mungbean, blackgram, and pigeonpea. However, it may also be necessary to study a limited number of major problems in grasspea and horsegram on account of their current importance in overall production.

Plant Protection

1. Entomology. Insect pests are often the most serious constraint to legume production, especially in warm humid climates. In Nepal, insects are more important in summer legumes than in the winter species. Highest priority should be given to developing effective and economic methods of control for the major pests of pulses, with major emphasis on the summer crops. Controls will surely involve the use of chemical pesticides (hopefully those formulations less toxic to humans and animals), use of biological agents, and alleviating cultural practices. A second high priority activity will be to work closely with plant breeders in screening for host plant tolerance to specific pests - if genetic differences for resistances are observed.

   Lower priority activities would be surveillance of pest build up and surveys/identification of the important pest species occurring in important growing regions during the different seasons. Separate yield loss assessments are probably not necessary if well-designed pest control experiments are carried out.

2. Pathology. Most field crop diseases can be economically controlled only by using resistant varieties; and sometimes by appropriate management practices. Thus, highest priority for legume pathologists would be to collaborate closely with plant breeders in screening germplasm for resistance to the major legume diseases; and participate in the incorporation of resistance into improved varieties. Cultural practices tending to reduce disease incidence and loss should also be investigated particularly in the early stages before there is time to breed for resistance.

Other pathological studies with lower priorities are surveys of disease incidence in the important growing regions of the country, and identification of new diseases. The possible use of chemical pesticides except as seed treatments is not considered a viable option for grain legume production in Nepal.

3. Nematology. Nematodes may pose a constraint to grain legume production under some conditions in Nepal. If nematodes are suspected, pulse scientists should solicit nematologists from other departments of DOA for help in identifying species, assessing the extent of damage, and screening of tolerant or resistant host plants. However, it is unlikely that the pulse program will require the the full time services of a trained nematologist, during at least the first phase of development.

Plant protection researchers should focus most of their attention on the major grain legume species on which genetic improvement is concentrated: lentils, chickpeas, soybeans, mungbeans, blackgram, and pigeonpeas. They should also be concerned with the systems in which these crops occur, such as whether a disease or pest is more or less damaging in different cropping patterns. Close association with cropping systems programs and socio-economists will be essential in determining whether a given control or pest management approach is viable.

Socio-Economic Studies

The role of socio-economics in grain legume improvement is as essential as that of any of the other scientists. The reason is that there are areas beyond the immediate concerns and competence of biological researchers, but which are funda-

mental to planning and developing improvement strategies. These include:

1. Interpreting statistics. Determining the impact of production trends and of import and export of food grains on grain legume production and improvement strategies.

2. Characterizing farmer motivations. This will involve studies on basic farmer motivations - why certain crops and production practices are used and what can motivate him to change. The socio-economics scientist is best equipped to identify and articulate what the farmer regards as his real needs. The basic tool used is 'on farm surveys.

3. Evaluating new technologies. Socio-economists are best qualified to assess the impact of new technologies on the farmer and on the local community. These studies are most useful in the late development rather than after attempts are made to transfer the technology. Perhaps the best vantage point for socio-economists is between pulses and the Farming Systems Program.

These and other socio-economic studies will require detailed on farm surveys which can also be designed to clarify some important biological questions.

Production and Seeds

The Pulses Program should be completely vertically integrated from the different levels of research through to the final product growing in farmers' fields. This must include direct participation in accelerated production schemes like the District-Based Intensive Production Programs focussed on

optimal cropping systems. It will also involve close cooperation with seed production agencies like the NIC in supplying adequate quantities of breeder's seeds, training of technicians, trouble shooting on problems, and initial field inspections of newly-released varieties.

It is also incumbent upon pulse scientists to remind appropriate, R&D planning and regulatory agencies of their essential roles and responsibilities in production. Government intervention will be essential in: (i) assuring the timely supply of inputs (e.g. fertilizers, seeds, inoculums, (ii) providing reasonable credit, (iii) guaranteeing producer prices, (iv) fostering farmer cooperatives, and (v) generally promoting pulse production through various communications channels.

Working targets: Phase I

The Department of Agriculture (DOA) follows a system of evaluation (targets) expressed in terms of specific activities or tasks like: (i) number of experiments, (ii) minikits/farmers' trials, (iii) publications (extension type), and (iv) foundation seed production. The targets established for Phase I of the pulses program are as follows:

Year	Experiments	Minikits/ FFT's	Publications	Found Seed Production
1984/85	35	1000	-	5 ha
1985/86	41	2000	2	5 ha
1986/87	45	2000	4	7 ha
1987/88	50	3000	6	10 ha
1988/89	50	3500	8	15 ha
1989/90	50	4000	10	18 ha

These activities targets may be most useful in determining support staff requirements and estimating operational budgets, rather than as a measure of meaningful productivity per se.

PHASE II

The long term program will have many of the some components as in Phase I, but germplasm collecting should have been completed by the end of the 1980's. However, trends in production and use should be clearer by 1990 justifying some change in emphasis in plant improvement. The need for plant breeding is expected to increase; while management and plant protection practices will continue to be refined and adapted for new crop varieties. Program involvement in production and seeds is likely to expand considerably. In other respects Phase II should be easier and more manageable if two separate - but closely linked - sub-programs, each with its own joint coordinator, are established from the present program ((i) the Tarai/Inner Terai; and (ii) Hills/Valleys). These and other projections for Phase II are further amplified below:

Plant improvement

Staff and resources should improve during Phase II, especially when a cadre of young staff completes their initial training. The technical program of genetic improvement being long term in nature will continue as in Phase I with possible expansion into new crops as shown below:

1. Lentils: Continue as a high priority program along the lines described for Phase I.
2. Chickpea. Continue as in Phase I; but increase crossing activities within Nepal.
3. Soybeans: Continue high priority programs with greater emphasis on breeding in Nepal.
4. Blackgram. Expand as a full-blown improvement program with major emphasis in the Hills and Valleys.

5. Mungbean. Expand or reduce program depending or production trends.

6. Cowpeas. Expand breeding if early expectations of potential are realized.

7. Pigeonpeas. Expand improvement, commence active recombination in Nepal.

8. Fieldpea: Continue modest testing program, unless the crop finds a better niche.

9. Grasspea. Discontinue observations and testing if crop appears declining in importance.

10. Horsegram. Continue testing and observations unless production declines.

11. Broadbean. Raise priority level and expand program in collaboration with ICARDA, if production increases significantly.

12. Phaseolus beans. Increase testing if crop catches on; collaborate in CIAT's testing program.

13. Other species. No special activities or program unless justified by unforseen developments.

Among the secondary species (items 8 to 12 above), the ones most likely to increase in importance are: broadbeans, Phaseolus beans, and possibly guar. Broadbeans are already expanding rapidly in the Kathmandu Valley, and adjoining areas, where moisture is reasonable and winters are cool.

Management and growth

Crop husbandry research should be continued along the lines previously described for Phase I. By the 1990's there will be clearer indications of which legume species are important in Nepal or are emerging in the economy. Obviously, there

should receive higher priority in crop management studies. These and some other new lines of investigation are proposed as shown below:

1. Cultural practices. Continue previous work adapting technologies to new varieties and species as they 'emerge'. In addition, begin exploring new areas like: minimal tillage (with herbicides), alley cropping, 'line' mulching, more effective use of 'dead' mulches, and appropriate mechanization.

2. Cropping systems. Continue studies on new technologies 'on the farm' in close collaboration with farming systems. Search for new roles and niches for legumes, especially in changing situations. Develop separate production 'packages' for rapidly expanding irrigated lands.

3. Microbiology. Commence testing comparative efficiencies of both introduced and locally collected Rhizobial cultures. Work out efficient methods of producing inoculum locally (in Nepal). Collaborate with plant breeders in screening genetic lines (legumes) for more efficient N^2-fixation.

4. Post harvest handling. Commence limited studies on the special problems of legumes for handling and storage, with emphasis on low-cost, solar drying and pest-free go-downs. Problems of splitting and cracking in threshing may also need some attention.

5. Appropriate mechanization. The problem of increasing operational efficiency will become increasingly important at the subsistence level of agriculture. Major constraints in growing crops involve basic tillage, inter-cultivation/weed control, and harvesting/

threshing. Among the options available the use of back-pack sprayers in minimal tillage systems and later in selective weed control is particularly attractive. Also, simplified, low-cost IRRI-type threshers may be suitable for use on several crop species either as individually-owned or custom-hired machines. More efficient ox-drawn implements (from ICRISAT and India) is another development that should be explored, but in a wider context than the grain legumes.

Plant Protection.

The research activities described for plant protection under Phase I would be continued in Phase II unless breakthroughs in pest control are achieved; or the species being studied is no longer commercially important. On the other hand, emerging new species should be added to the program as discussed under previous sections. Additions and modifications in plant protection research relevant to grain legumes may include:

1. Entomology. Continue emphasis on insect problems of major species as well as any emerging new legumes. Expand studies of pest life cycles, natural predators, and microbiological agents of major pests. Introduce some of these predators and natural controls into Nepalese cropping systems. Continue screening some of the more promising new pesticides, especially those with low mammalian toxicities. Study the effects of different crop associations, relays and sequences on pest dynamics (with cropping systems). Begin developing comprehensive integrated pest management methods for Nepalese conditions and use patterns.

2. Pathology. Continue programs outlined for Phase I, but add emerging new species and/or discontinue those no longer important to the national economy. Attempt to gain a better understanding of why some diseases occur and spread under certain conditions.

   Expand and accelerate screening and resistance breeding of less tractable diseases of major legume crops; investigate the effect of different cropping associations and patterns on the occurrence and severity of diseases; study possibilities for new, systemic seed treatment chemicals for controlling seed and soil borne pathogens.

   Develop comprehensive disease management regimes for Nepalese conditions utilizing combinations of host and plant resistance, alleviating cultural practices/cropping systems, and seed treatment chemicals, if applicable with Farming Systems Program.

3. Nematology. Continue investigations described under Phase I if warranted. If certain nematode species prove important, expand screening and breeding for host plant resistance. A second area worthy of study is alleviating cultural practices and cropping patterns. Previous experience with root knot nematodes in the tropics shows that most legume species are susceptible, but diverse plant populations carry resistance. Screening may be simple; examine the roots of all selected plants.

Socio-Economics:

The role of socio-economists will become increasingly important as close partners of biological scientists in evaluating new technologies and species both for farmer acceptance

and impact on the economy. Another important function will be as agents of change, deriving from continuing studies of real farmers'problems and motivations and knowledge of promising new technologies on the horizon. Moreover, socio-economists must continue to participate in developing new strategies and the seasonal work planning sessions.

Product Quality.

A new functional area is proposed to be added during the first half of the 1990's decade - a biochemist. Although this scientist would lead the new functional group on product quality, some specific activities of the section would include:

1. Evaluating product quality. This would involve (i) screening of legume seeds for (a) cooking quality of pulses and vegetables and in various food preparations and (b) nutritive values of different pulses and their genetic variants; (ii) participation in breeding for enhanced nutritional quality in pulses - especially for increased proteins and sulfer amino acids (if deemed sufficiently important and time permits); (iii) biochemical evaluation of legume foliages/crop aftermaths (with breeders, agronomists, soils scientists and others).

2. Plant nutrition and growth. This area includes effects of soils, climate, moisture, and management factors on plant growth as determined from tissue analysis at different stages of growth. Participate in studies on the use of plant hormones and weedicides as appropriate and desirable. Monitor qualities of fertilizers and agricultural chemicals, if necessary; and determine the major and minor nutrient availability of various mulches and crop residues (with plant physiologists, soil scientists, agronomists, entomologists).

3. Monitoring contamination. This could include analysis of pesticide residues in the food chain, drinking water, soils, and stock feed (mainly with plant protection scientists).

Production and seeds.

Program participation in accelerated production schemes and in seeds is anticipated to expand considerably as new technologies become available, and areas covered by pulses increase during Phase II.

This range of activities could easily result in a work overload for a one-scientist section. However, the biochemist should not be burdened with routine soil and tissue testing when these can be done better elsewhere (including commercial laboratories). Moreover, the biochemist must be well versed in using, operating and maintaining the newer, simpler, and faster instruments for crop sampling like the modified micro-Kieldahl system for protein analysis, infrared reflectors (for several components), and others. In fact, major contributions will also be made in interpreting results ; participing in planning; and developing more effective, faster, and economic methods of screening /evaluating.

Working targets - Phase II.

Assuming the Pulses Program will be fully operational by the end of the decade, all staff will have been recruited , necessary facilities provided, and proposed Phase II expansion is approved and implemented, it should be possible to achieve the following activities targets during 1990 to 2000:

Phase II Targets:

Year	Experiments	Minikits/ F. Trials	Publi-cations	F. seed production
1990/91	55	4000	10	20 ha
1991/92	60	5000	10	25 ha
1992/93	70	5000	15	28 ha
1993/94	70	6000	15	35 ha
1994/95	85	6500	20	35 ha
1995/96	105	7500	20	40 ha
1996/97	110	8000	20	43 ha
1997/98	125	8000	25	45 ha
1998/99	135	9000	30	50 ha
1999/2000	155	9000	30	55 ha

The breakdown of this program is broadly estimated to be: (i) soybeans = ca. 20 percent, (ii) winter legumes = 35 percent, and (iii) summer legumes = 40 - 45 percent.

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THE CONSULTANCY

BIODATA ON EXTERNAL CONSULTANT

Kenneth O. Rachie. Born on October 15, 1923 and reared on a farm in south-western Minnesota. He completed B.Sc., M.S. and Ph.D.degrees in Plant Breeding and Agronomy at the University of Minnesota (1954). He then joined the University of Arizona as a forage crops specialist and served as Professor of Field Crops at Abu Ghraib College of Agriculture near Baghdad, Iraq, for one year, (UA/USAID contract). On October 1, 1955 he joined the Rockefeller Foundation to serve in the following capacities.

- Plant geneticist, sorghum and millets: Mexico (1955 - 57) and India (1957 - 67).
- Professor of Plant Breeding: Makerere University, Kampala, Uganda (1968 - 1971).
- Assistant Director and Program Leader, Grain Legume Improvement Program: IITA, Ibadan Nigeria (1971-75) .
- Associate Director General (Research): CIAT, Cali, Colombia (1975 - 78).
- Program Officer (Associate Director): The Rockefeller Foundation, New York (1979 - 82).
- Chief of Party, Sumatra Agriculture Research Project (USAID/IADS contract) - Padang, W. Sumatra, Indonesia (1982 - 84).

Rachie has also served on several short term missions of four weeks or longer with the Rockefeller Foundation, IADS, USAID and World Bank to Niger, Ethiopia, Uganda (1980), mainland China, Zambia and Nepal. Major research accomplishments include: contributions to the development of sorghum and pearl millet hybrids in India; tropical cowpeas, soybeans, and pigeonpeas at IITA (Nigeria); and in establishing the first World collec-

tions of sorghum and millets, and tropical grain legumes. Other activities have involved agricultural research administration and grants-in-aid in support of plant research. He retired from the Rockfeller Foundation after 29 years of service on September 1, 1984. At present he holds two part time appointments:(1) IADS Representative; and (2) University of Florida Adjunct Professor of Plant Pathology.

CONSULTANT ACTIVITIES
MARCH 18 - MAY 13, 1985

Date	Activity and Contacts
March 18 - 20	Travelled from Clermont, Florida to Arlington, Virginia (IADS Headquarters) for briefing on Nepal assignment: R.R. Harwood, F.C. Byrnes, A.C. McClung, G.B. Baird, S. Dewey and others.
March 21 - 24	Travelled from Washington, D.C. to New Delhi, India: consulted with Indian Agricultural Research Institute (IARI) professional staff, and Indian Council for Agricultural Research officials on the status of grain legume and finger millet research in India; and collected some key reference materials. A. IARI: B. Baldev, Pulses Research; Dr. Munshi Singh, Head of Botany Division; Dr. M.P. Singh, Cytogenticist. B. ICAR: Dr. M.V. Rao, Deputy Director General (Crops).
March 24	Travelled from New Delhi to Kathmandu; met with staff at Khumaltar for briefing on assignment: - A.N. Bhattarai - Head of Agronomy Division - M.P. Bharati - Pulses Agronomist - D.B. Tamang - Cropping Systems Agronomist - M.L. Malla - Production Coordinator (CSP) - J.R. Joshi - Agronomist (Pulses) - J. Tamulonis - PCV, Finger Millet - B.K. Singh - IADS/ICP Agronomist (CSP)

Date	Activity and Contacts
	- S.L. Shrestha - Agronomist (CSP) - K.N. Singh - Agronomist, Minor Cereals - B.K. Gyawali - Legume Entomologist - K.D. Sayre - IADS/ICP (CSP) Senior Research Agronomist - C.N. Hittle - IADS/ICP, Project Supervisor
March 25	Kathmandu - morning and afternoon meetings. A. DOA meeting: - P.P. Gorkhaly, Director General - A.M. Pradhanang, Deputy Director General, Crops - A.N. Bhattarai, Head of Agronomy Division - C.N. Hittle, IADS/ICP - M.P. Bharati, Agronomist B. Khumaltar-Plant Pathology/Entomology/Soils: - Purush M. Amatya - Chief Plant Pathologist - Keshav Ch. Sharma - Chief Entomologist - Dhruba Joshi - Soil Scientist C. Agriculture Inputs Corporation (AIC): - K.B. Rajbhandary - General Manager - A.N. Bhattarai - Chief, Agronomist, Khumaltar - C.M. Manandhar - Production Officer - B.P. Parajuli - Production Officer - A. P. Singh - Production Officer
March 26	Travelled by road to Parwanipur Agriculture Station with ICRISAT scientists and Dr. M.P. Bharati; overnight in Birgunj. A. ICRISAT Staff - Y.L. Nene, Program Leader for Grain Legumes (Pathology) - Onkar Singh, Chickpea Breeder - K.B. Singh, Pigeonpea Breeder

Date	Activity and Contacts
	B. Parwanipur Staff: - R.P. Shah - Pulses Improvement Specialist - R.P.Chaudhary - Rice Improvement (Agronomy)
March 27	Travelled to Nawalpur Agriculture Station (Sarlahi Station), Janakpur (Japanese Agriculture Development Project), and Hardinath. A. Sarlahi: - M.K. Jayaswal - National Oilseeds Development Program (Sarlahi) - D.S. Pathic - do & Oilseeds Coordinator B. Janakpur/Hardinath: - B.N. Karmacharya - Agricultural Officer, JADP
March 28	Travelled from Janakpur to Biratnagar, visited the Jhumka seed Multiplication Farm - Chit Ranjan Yadav - Farm Manager
March 29	Travelled from Biratnagar to Kankai Irrigation Farm (S.E. corner of Nepal) and returned to Biratnagar: - K.P. Dhungana - Agronomist
March 30	Travelled to Tarahara Agriculture Station and to Dharkuta. A. At Tarahara we met: - Bharat Dangol, Station Director - D.N. Chaudhary Assistant Agronomist B. At KHARDEP in Dharkuta (Koshi Hills Area Rural Development Project) we met: - Nick Foster, Irrigation Engineer (PG Student)

Date	Activity and Contacts
	David Handley-Clarke, Cartographer Anthony (Tony) Willet, Agricultural Advisor, ODA
March 31	Travelled to Hills and trekked 1½ hours to Pakhribas Agriculture Center (ODA financed); toured the station and met: - J.D. Moir, Manager, PAC - Terry Green, TCO Agronomist - H.B. Thapa, Extension Officer - S.P. Chand, Assistant Agronomist
April 1	Travelled from Pakhribas to Birgunj: arrived at 7 p.m. (no stops)
April 2	Birgunj to Kathmandu (arrived at 5 p.m.) with stops at: A. Bhandara Fisheries Development Centre - about 20 Km. east of Bharatpur. B. Yaeyapuri Chitwan Horticultural Farm - about 2 Km. from Bharatpur. C. Rampur Agriculture Station/Institute for Agriculture and Animal Sciences (IAAS) - about 6 Km. from Bharatpur: - Vishnu Sharma, Maize Coordinator - Kaushal K. Lal, Maize Breeder
April 3 - 17	Kathmandu: working on report and attending following meetings with HMG/N officials and others: A. DOA - on April 16. B. Khumaltar - April 3, 7, 9, 11, 15, 16 C. USAID - April 3, 5, 9:

Date	Activity and Contacts
	- Gary E. Alex, Agriculture - J.R. Kansakar, Engineer - Dharma R. Suwal - Accounts
	D. IDRC - April 15 - 17: - K.J. Riley, Program Officer (N. Delhi) - H.P. Bharati, DOA Agronomist
	E. ICP/SPIS/IADS - daily: - Carl N. Hittle, Project Supervisor (ICP) - S.S. Ral, Project Supervisor (SPIS) - K.D. Sayre, Agronomist (CSP) - J.H. Freeman, Consultant, IADS/ICP - M.Kalim Qamar, Extension Specialist, IADS/AERP - R.R. Harwood, Program Officer (Asia), IADS - R.N. Iltis, Consultant, IADS/ICP - J. Tamulonis, PCV (millets)
April 18	Travelled by road to Jiri and Kabhre Agriculture Farm (1700 m.); enroute visited the Bonch Integrated Hill Development Farm (Swiss support); trekked one hour into Kabhre Farm: - Kedar Nath Adhikari, Asst. Agri. Officer - Magher Hussain Kalim, Asst. Agric. Officer
April 19	Returned to Kathmandu about 5 p.m. stopped enroute at the Panchkhal Horticulture Farm about 45 km. east of Kathmandu: - Bhola Adhikari, Officer-In-Charge
April 20 - 30	Kathmandu: worked on report and held followup meetings with various agencies: ICP, SPIS, Khumaltar (Agronomy Division), USAID. Also attended

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Date	Activity and Contacts
	meetings with Winrock, IADS, and ADC officials: - R.D. Havener, President (Winrock International) - A.C. McClung, President (IADS) - T.M. Smith, President (ADC) - J.C. Cool, Project Supervisor (ADC/Nepal) - M.B. Wallace, Field Staff Member (ADC/Nepal) - ICP/SPIS Field Staff (Previously noted).
May 1 - 9	Kathmandu: held several meetings with ICP, SPIS, USAID, Khumaltar and DOA officials; completed consultancy report on grain legumes (with M.P. Bharati); and prepared a draft proposal for IDRC funding for the Pulses Program.
May 10	New Delhi: met with Dr. K.W. Riley and colleagues on the Pulses Program proposal.
May 11 - 13	Travelled by air to London (2 nights) and Orlando, Florida (arr. 7.30 p.m.) Terminated assignment.