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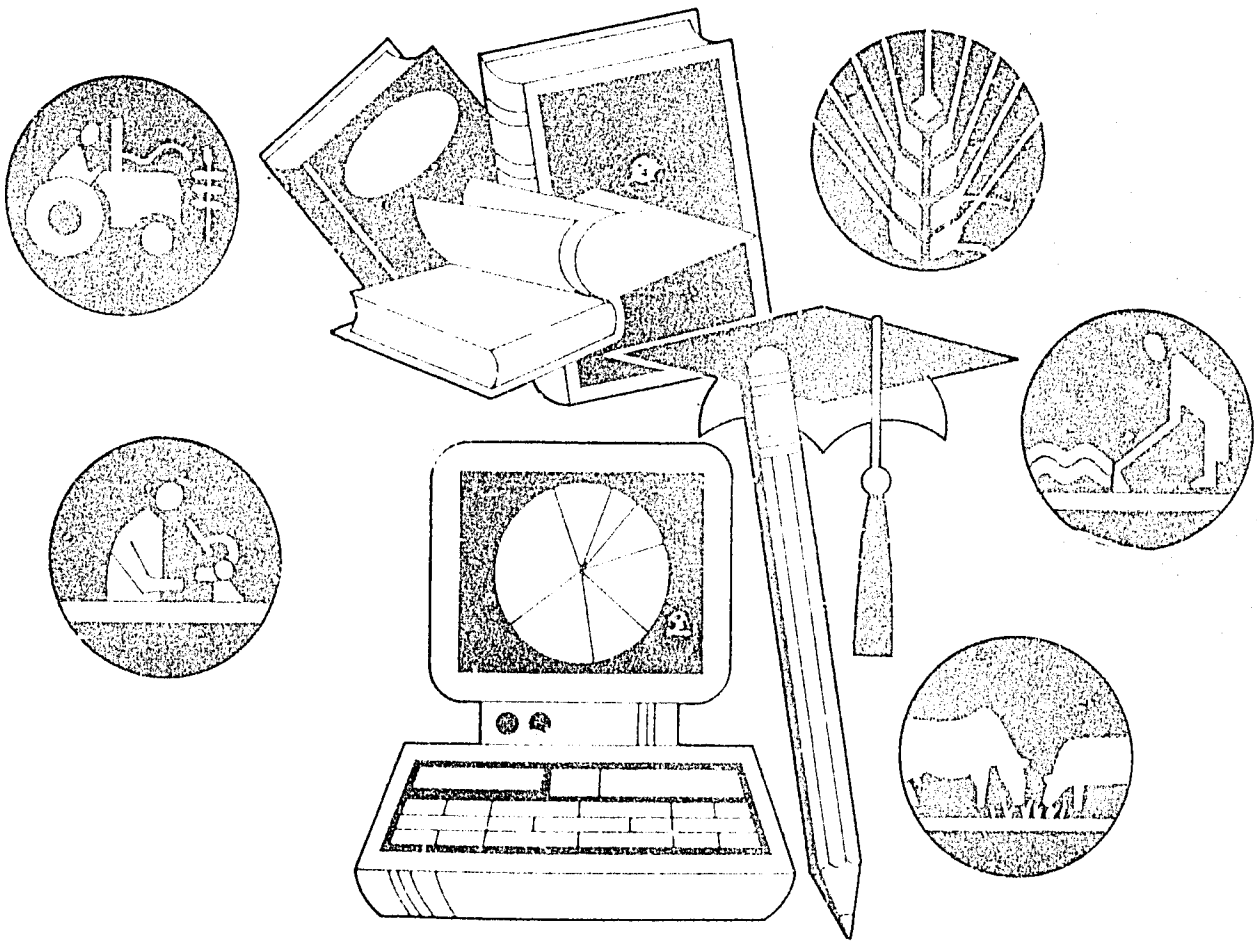
NATIONAL AGRICULTURAL RESEARCH CENTRE :

MASTER PLAN 1988 - 2000

Volume I. Research Master Plan



Pakistan Agricultural Research Council
Islamabad
1989

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MASTER PLAN 1988 - 2000

Volume I. Research Master Plan

1989
Pakistan Agricultural Research council
P.O.Box 1031, Islamabad

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Foreword

The National Agricultural Research Centre is a multidisciplinary research institute, conducting research on crops, animals, natural resources, and rural social sciences in both the field and laboratory. The master plan provides guidelines for NARC's future research programmes and physical plant development up to the year 2000. The plan is in two volumes. Volume I is the Research Master Plan. Volume II is the Physical Plan.

Why is a master plan important? There are many reasons. It is important to prioritize research problems so that research can be directed at the most critical issues, while coordinating NARC's research with the research programmes of provincial research institutions to minimize duplication or gaps in the national research effort. This master plan also provides information to ensure that resources are allocated to the highest priority research for the highest potential payoff. Moreover, the master plan serves as a basis for planning the development of NARC's human resources and physical facilities.

However, there is an important caveat to be noted. A master plan is not static; it is not set in concrete, good for all time. It is, in fact, applicable to only one point of time and must be continually revised and updated to reflect the continually changing conditions of the real world. The implementation schedule for this master plan will have mechanisms built into it for periodic revision.

This master plan is the first to be prepared by a major agricultural research institute in Pakistan. It is my hope that this plan will inspire similar efforts by other research institutes and that the plan will serve as a useful model for them.

Dr. Amir Muhammed
Chairman, PARC

November, 1989

Preface

The Research Master Plan must be understood for what it is—a blue print to guide the direction, scope and kind of research in which NARC will engage. The products of research are new technologies and services to farmers. Research programmes fulfill their mission only when millions of farmers benefit from better seed and improved technology, markets and management. An important goal of NARC research is to generate superior technology which can be readily adopted and accelerate the change in conditions facing small farmers. The aim is to conduct research which will provide an increase in sustainable agricultural/livestock productivity and raise farmer income.

In the past, emphasis has been placed on commodity research and certain segments of scientific enquiry. This will continue. But NARC will give a new impetus to interdisciplinary studies that address complex production constraints. A systems research approach is emphasised where research thrusts call for an integrated disciplinary effort. While biotechnological research will provide new genetic tools to improve plants, animals and products, intensive inputs from breeders, soil scientists and complementary disciplines of entomology, pathology, physiology are also recognized as priority research components of this master plan. An accelerated social science research programme is articulated.

The three-fold purpose of the NARC Research Master Plan is to enable the administrators to assess where research priorities should focus, how researchers may become more effective, and where resources should be allocated. Actions necessary to develop a Centre of Research Excellence are suggested. Programme leaders should be assisted to plan, implement and monitor interdisciplinary studies to resolve priority production constraints faced by farmers. Indeed the master plan informs planners, policy makers, and donors of the NARC research thrusts and resource needs to supplement provincial research.

The NARC Research Master Plan is the product of a combined effort of NARC staff, senior provincial scientists, PARC members and directors, and overseas consultants. The experience of contributing consultants and Pakistani scientists encompass most biological and social sciences. Many scientists with considerable research management experience participated. Subsequently about 50 experienced leaders, scientists, technologists and administrators read and commented on an early draft. The seven step methodology from plan inauguration through staff questionnaire, sector reviews, formal programme presentations, master plan symposium culminating with a draft and senior panel review are described in chapter 2.

Chapter 3 concerns research programmes and projects with manpower and operational resource allocation. Chapter 4 covers research organization and management while chapter 5 is devoted to support services.

Those contributing to this NARC Research Master Plan hope it helps administration and programme leaders plan and conduct research on priority problems and allocate resources accordingly. Moreover the master plan should be a model for other institutions to follow such that a strengthened and closely coordinated national research system better serves the farmer.

Dr. M. Yousaf Chaudhri,
Director General, NARC
and
Dr. M. D. Dawson,
Advisor (Farming Systems
Research), MART Project

September, 1989

Writing Team

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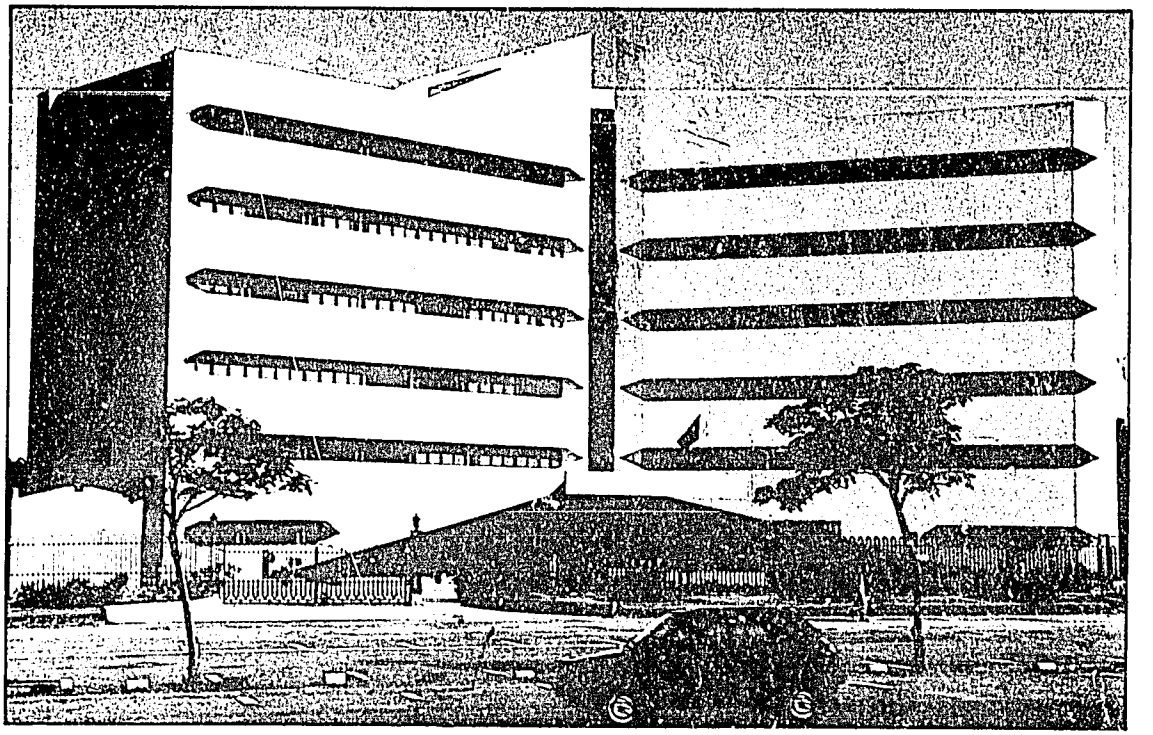
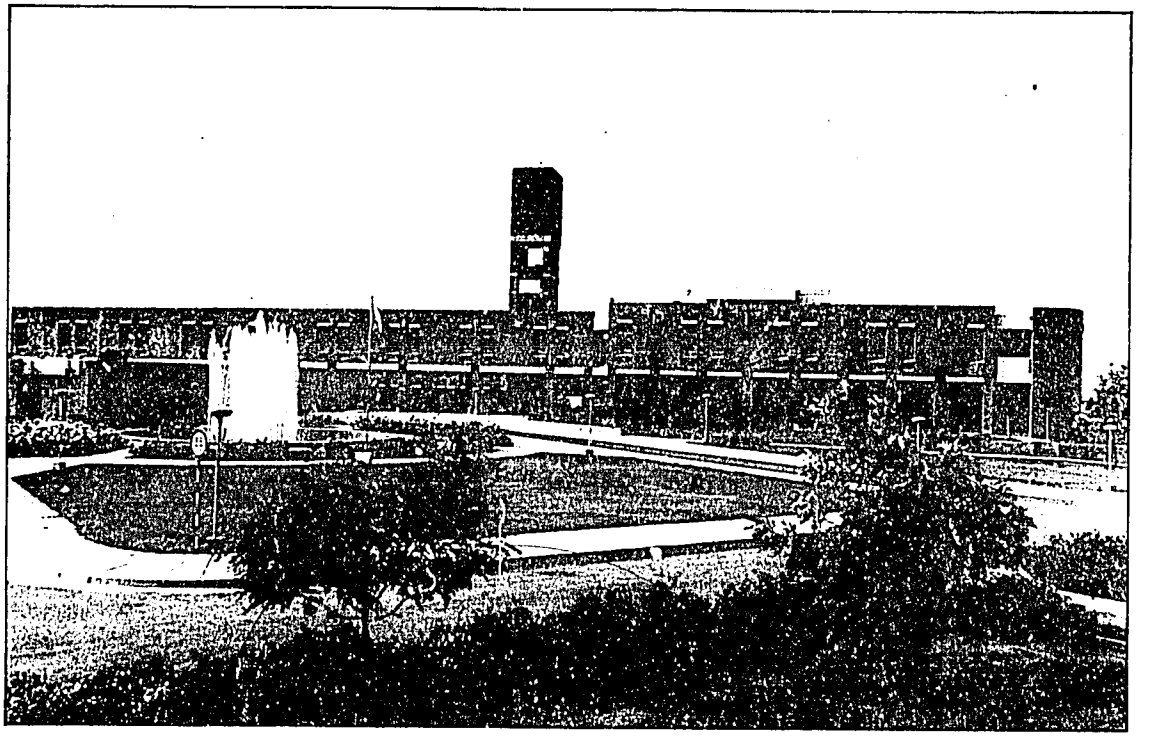
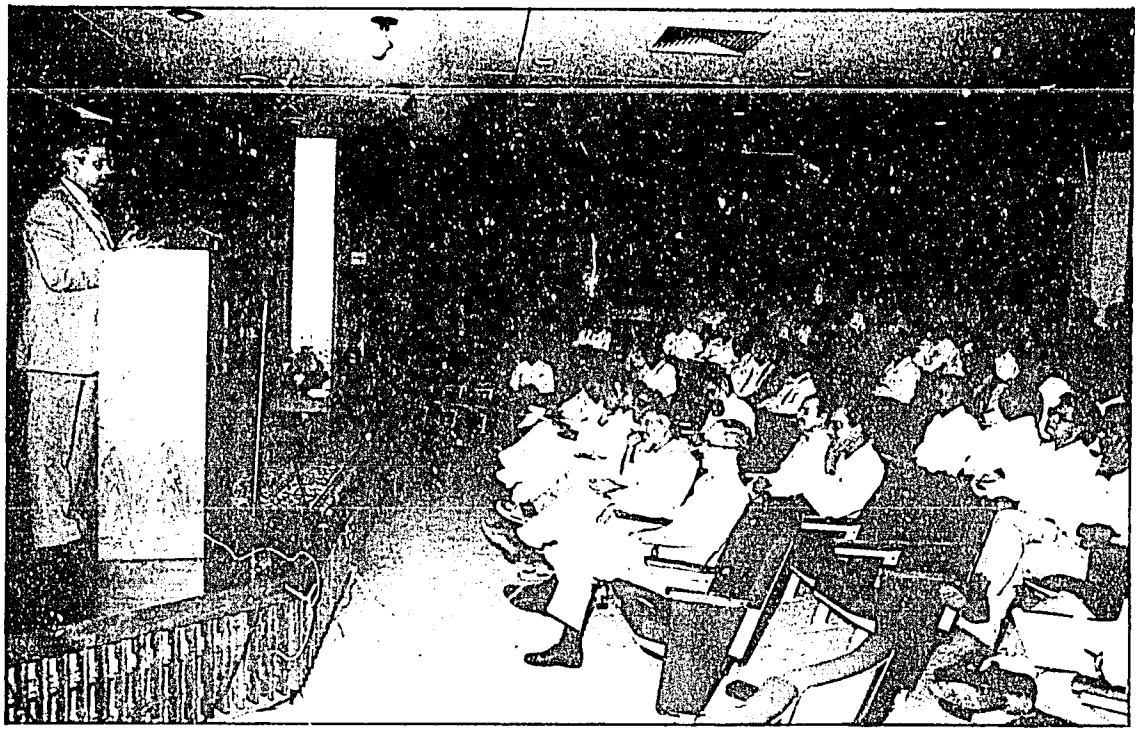


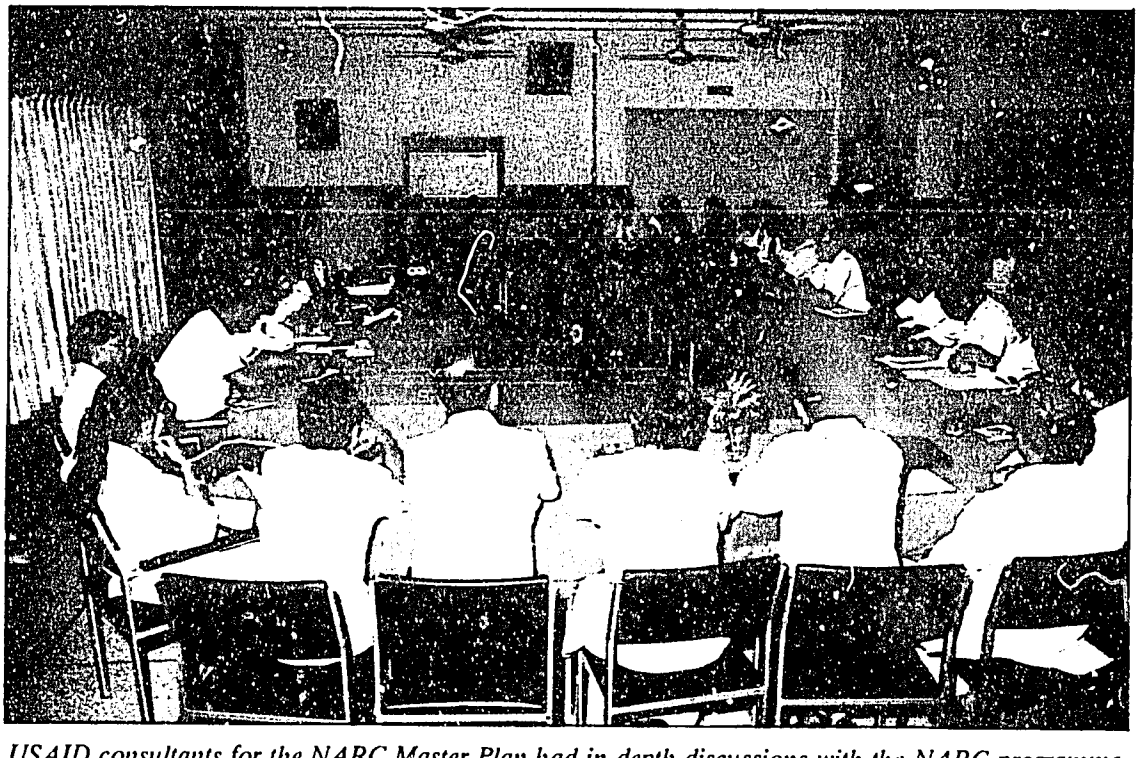
The Pakistan Agricultural Research Council (PARC) is the apex national agricultural research organization. Its main purpose is to strengthen Pakistan's agricultural research system, comprising the federal and provincial institutions with a view to promote agricultural development in the country.



The National Agricultural Research Centre, Islamabad, is the premier multi-commodity and multi-disciplinary facility of the Pakistan Agricultural Research Council, conducting research for the resolution of intricate agricultural problems to enhance farm productivity.



Dr. Amir Muhammed, Chairman, Pakistan Agricultural Research Council, addressing the NARC scientists on the importance of Master Research Plan, its use in establishing research priorities, the importance of inter-disciplinary studies and how resources will be allocated according to the priority programmes.



USAID consultants for the NARC Master Plan had in-depth discussions with the NARC programme leaders before finalization of its various components.

NARC Programme Leaders

Dr. N. I. Hashmi	Wheat, Barley & Triticale
Dr. M. Ashraf	Rice
Dr. M. Aslam	Maize
Mr. Abdul Shakoor	Sorghum & Millet
Mr. Mohammad Banaras Bhatti	Fodder Crops
Mr. Bashir Ahmed	Pulses
Dr. Amjad Masood Rana	Oilseeds
Dr. Mohammad Ashraf	Vegetables
Mr. Z. M. Niazi	Fruits
Mr. Rashid Anwar	Seed Science and Technology
Mr. K. B. Malik	Sugar Crops
Mr. Rashid Anwar	Plant Genetic Resources
Dr. Zahoor Ahmed	Plant Introduction Centre
Dr. Abdul Majid	Farming Systems Research
Dr. Mohammad Aslam	Crop Diseases Research Institute
Dr. S. M. Mughal	Plant Virology
Dr. C. Inayatullah	Entomology
Dr. Rashid A. Shad	Weed Sciences
Dr. M. Salim	Land Resources
Mr. Sharif Zia	
Dr. A. Rashid	
Mr. Rehmatullah	
Dr. Muzaffar A. Khan	
Dr. Zaib-un-Nisa Abdullah	
Dr. Shahid Ahmed	Water Resources
Dr. Noor Mohammad	Agro Forestry
	Forage and Pasture
Dr. Parvez Naeem	Remote Sensing
Dr. Azra Quraishi	Tissue Culture
Dr. H. I. T. Khawaja	Cytogenetics
Dr. M. Akmal Khan	Food Technology
Dr. Iftikhar A. Rana	
Dr. Rafiq Ahmed	Apiculture
Dr. Rafiq Ahmed	Sericulture

Mr. Riaz Khalid Siddiqui	
Dr. Mumtaz Ahmed	BARD
Dr. Ulfat-un-Nabi Khan	Animal Breeding & Genetics
Mr. Nasim Ahmed	Reproductive Physiology
Mr. Naeem Iqbal	
Mr. M. Anwar	Embryo Transfer
Dr. A. S. Alvi	Meat Production
Mr. Azhar H. Athar	Dairy Technology
Mr. Arshad Hussain Shah	Poultry
Dr. Amanat Ali	Animal Nutrition
Dr. Ashiq H. Cheema	Animal Health
Dr. M. Afzal	
Mr. M. A. Naqvi	Sheep and Wool
Dr. Nasim Akhtar	Fisheries
Mr. Mushtaq Ahmed Malik	Scientific Information and Publication
Mr. Naseer Alam Khan	Computer and Statistics
Dr. M. S. Khan Rana	Training Institute
Dr. M. Sarwar	
Dr. Waqar Ahmed	Technology Transfer
Mr. Khalid Masood	Technology Transfer (ICT)
Mr. Ikram Saeed	Agricultural Economics Research Unit
Dr. S. Iqbal Ahmed	Farm Machinery Institute
Mr. Mohammad Idrees	Central Stores
Mr. Zafar Hameed Hashmi	Laboratory Equipment and Maintenance
Mr. Abdul Ahad	Farm Operations and Services
Mr. Mohammad Aslam	AGS "Procurement Cell"
Mr. Nawaz Ali Shah	Automobile Workshop
Mr. Mohammad Idrees	Transport Section
Dr. M. Anwar Hassan	Audio visual Communications
Mr. Aftab Ikram	Works, Repair and Maintenance

Acronyms

AERU	Agricultural Economic Research Unit
AVRDC	Asian Vegetable Research and Development Center, Taiwan
CGIAR	Consultative Group on International Agricultural Research, USA
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture), Columbia
CID	Consortium for International Development, USA
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Center), Mexico
CIP	Centro Internacional de la Papa (International Potato Center), Peru
FAO	Food and Agriculture Organization of the United Nations, Italy
FSR	Farming systems research
ICARDA	International Center for Agricultural Research in Dry Areas, Syria
ICRISAT	International Crops Research Institute for Semi-arid Tropics, India
ICT	Islamabad Capital Territory
IITA	International Institute for Tropical Agriculture, Nigeria
ILCA	International Livestock Center for Africa, Ethiopia
ILRAD	International Laboratory for Research on Animal Diseases, Kenya
IRRI	International Rice Research Institute, Philippines
PGR	Plant Genetic Resources
TAC	Technical Advisory Committee, Consultative Group on International Agricultural Research, Italy
USAID	United States Agency for International Development, USA

Summary

Introduction

In terms of contribution to national income, employment, markets for industry, and supply of raw materials and products for export, agriculture is the foundation for Pakistan's economy. It contributes 26% of GDP, which makes it the largest single sector of the economy. Between 1960 and 1985, the agriculture sector grew at 3.6% a year. Since 1977, the livestock sector has expanded more rapidly than the crop sector. New technology was the major sources of growth in crop output until the early 1970's. Since then, crop output gains have resulted mainly from higher cropping intensity made possible by increased irrigation from tubewells and dams. In recent years crop yields have not improved significantly.

Historically, agricultural research in Pakistan has suffered from shortage of qualified scientists at the national and provincial levels, poorly defined research priorities, lack of equipment and facilities, weak connections between research, education, and extension, failure to insititutionalise the research system, and inadequate coordination.

The Sixth Five-year Plan stressed greater self-sufficiency in crops and diversification to increase productivity and exportable surpluses. Research was seen as necessary to achieve higher yields. However, targets for diversification and exports were not reached due to inadequate implementation of research, extension, and developmental activities. The seventh plan emphasizes improved organisation and integration of agricultural research. Specifically it calls for basic research by PARC and more applied research by provincial institutes. It stresses better varieties in crops like oilseeds, pulses, rice, sugarcane, and fruits and vegetables; better nutrition for livestock; and the development of better production systems for less-favored environments.

At independence, Pakistan had provincial research organisations, but it was left with none of the central research institutes that had been established in pre-partition India. The steps to establish a national research system occurred in the late 1970's and early 1980's. In 1981 PARC was made fully autonomous and a World Bank project was approved that supported large-scale advanced training for agricultural scientists, construction of facilities for PARC and NARC, and increased funding for various research programmes and institutions.

NARC is primarily intended to undertake research on complex agricultural problems which require technical expertise and sophisticated laboratory facilities. It also provides training, information, data processing facilities, laboratory equipment maintenance and repair facilities, and a germplasm bank. The coordination of national research activities among the provincial research institutes and NARC is done by PARC. NARC receives nearly all its funds from PARC. In recent years the NARC budget has not grown. NARC has benefited from the near doubling of trained agricultural scientists which has occurred in the last decade. However, the proportion of

Ph.D.'s among the scientists has remained unchanged. NARC has 49 Ph.D.'s and is short of professional leadership in a number of areas. NARC's physical facilities include an administration building, auditorium, library, central laboratories, training institute, hostels, and cafeteria.

Research Plan

The NARC master plan demonstrates what NARC stands for, what it hopes to achieve, and the style of research it intends to use to the end of this century. It is the result of a year-long process involving a questionnaire sent to 200 scientists to elicit views on research priorities and gaps, informal programme meetings to discuss the results of the questionnaire, peer reviews of formal presentations by 37 project or programme leaders on planned research, a 3-day master plan symposium attended by national scientists, preparation of a draft master plan, and final review by a senior PARC panel.

NARC has established nine objectives around which its activities are organised:

1. Increase productivity and quality of priority crops—oilseeds, cereals, forages, pulses, and vegetables to improve farm income, with emphasis on small farmers.
2. Introduce, adapt and generate improved technology for "barani" areas on an integrated land use basis.
3. Improve processing and minimize losses of agricultural products for human consumption.
4. Establish an economically sound technology to improve livestock productivity.
5. Develop improved farming systems technology which optimizes resource management and packages for ready transfer.
6. Strengthen the national agricultural research system in conducting basic and applied research.
7. Facilitate the flow and documentation of scientific and technical information.
8. Develop quality training facilities and capability for national and international seminars, workshops, and training courses.
9. Accelerate the transfer of improved technology, methodology and information to increase agricultural production and net farm income.

Wheat and rice are the most important cereal crops. Substantial portions of the growing areas have adopted modern varieties, so further yield gains will have to come from other sources. In fact, yields of wheat and rice in recent years have shown little change. In *wheat*, NARC research will stress diversification of the genetic base for rust resistance and the development and wide testing of varieties. Varieties will be bred specifically for rainfed and problem soil areas. Also computer models will be created as a tool for better crop management. The *rice* programme will improve basmati rice through innovative means, develop direct screening technology, and evaluate germplasm for resistance to biotic and abiotic stresses. Other important areas will be improving varietal resistance to pests and developing cropping systems that reduce pest damage.

Yields of maize and sorghums and millets suffer from the uncertain conditions under which these crops are cultivated. The *maize* programme will focus on development of maize germplasm for tolerance to drought and cold. It will intensify screening of germplasm for resistance to stalk borer. It will use computer modeling to assess optimum input levels for maize under rainfed conditions. And it will seek better techniques for predicting combining ability in inbred lines for hybrid production. The *sorghum and millets* programme will emphasize collection and screening of local and exotic germplasm, particularly for tolerance to drought, heat, and salt and for ability

of seedlings to emerge through crusted soil. Breeding goals include dual-purpose (grain and forage) varieties and development of hybrids and composites. Improved technology will be demonstrated in farming systems.

Livestock production is critically affected by shortages of fodder. To help overcome this problem, the *fodder crops* programme will evaluate germplasm and develop varieties suitable for rainfed areas, along with improved production technology for farming systems. Promising varieties will be evaluated for nutritive value.

Shortages of pulses are chronic. Pulse production is crippled by a narrow genetic base, lack of high yielding, early maturing varieties, poor production technology and serious disease and insect problems. The *pulses* programme will focus on chickpea, lentil, mung, and mash. It will evaluate germplasm and breed varieties for high yield, short growth duration, drought tolerance, and disease resistance. It will develop improved technology involving better weed control, high plant densities, use of inoculations with rhizobia, and use of fertilizer.

The low yields of oilseeds have resulted in regular imports of edible oils by Pakistan. The *oilseeds* programme works on soybean, rapeseed and mustard, groundnut, linseed, and sesame and is introducing sunflower. The programme will collect, evaluate, and disseminate germplasm and conduct national trials. It will monitor the incidence of diseases and pests of oilseeds and develop control measures including pesticides and biological controls. It will promote various oilseeds for planting in fallow fields in cotton, rice, riverine, and rainfed areas.

The aim of the *sugar crops* programme is to make sugarcane and sugarbeet production more profitable through higher yields and lower input costs. The programme will develop sugarcane and sugarbeet varieties that are high yielding, resistant to diseases and pests and tolerant of frost, drought, and problem soils.

Vegetable production has not kept pace with demand. The *vegetable* programme will emphasize breeding chilies for resistance to phytopthora and tomatoes to TMV. Tomatoes and onions will be selected for better shelf life and higher yield. The *fruit crops* programme will improve the options available to fruit growers by introducing and evaluating germplasm, by asexual production of true-to-type plants of loquat and guava and development of seedless types, and by standardization of fruit production recommendations.

Plant genetic resources and *plant introduction* will enhance the range of germplasm available to crop scientists through introduction, collection, maintenance, and evaluation of a wide range of germplasm. The *tissue culture* program will develop new techniques for pre-basic seed production in potato, faster ways to select stress-tolerant lines in wheat, a micropropagation system for date palm, and a means for virus elimination in horticultural crops. *Cytogenetics* work will focus on developing both diploid and polyploid hybrids with desired genetic traits, on wide crosses in wheat, on new hybrids in grasspea, and on achieving sterility in tea.

The *Crops Diseases Research Institute* will diversify resistance of wheat to rusts, powdery mildew, and smuts; find sources of resistance to oilseed diseases through biotechnological methods; and identify root stocks resistant to crown and root rot of apple.

In *plant virology*, virus diseases of major crops will be identified and their importance and distribution will be determined to guide future research. Development of methods of purification of important viruses will lead to local antisera production and preparation of ELISA kits. In *entomology*, integrated pest management techniques will be developed for major crops, methods for control of stored grain insects will be developed, and computers will be used for pest forecasting and pest management. The *weed sciences* programme will emphasize integrated weed management through precise chemical application, cultural practices, identification of biological weed control agents, allelopathy, and identification of seedicides, dormancy breakers, and germinators.

To improve low producing cattle, the *animal breeding and genetics* programme will use selective breeding to upgrade cattle and buffaloes. It will develop a scientific basis for comparing cattle in terms of their performance and adaptation to local climate. In *reproductive physiology*, the emphasis will be on buffaloes—reducing the calving interval, improving methods for detecting estrus and for diagnosing pregnancy, and hastening sexual maturity. The *embryo transfer* unit will develop methods of embryo collection, preservation, and transfer that can be used by extension workers. The *meat production* unit will stress determining optimum age/weight relationships for meat production by small and large ruminants, economic use of slaughterhouse by-products, and standardizing a carcass-grading system.

The *dairy* technology unit will develop improved methods of milk collection in rural areas and better technology for farm level manufacture of milk products. To support the fast-growing poultry industry, the *poultry* unit will develop the capacity to evaluate different strains and breeds of commercial broilers and layers under Pakistani conditions.

Animal nutrition work will emphasize means to use agricultural wastes and industrial by-products in livestock rations. It will develop technology for producing complete formal feeds and urea-molasses blocks. And it will evaluate the nutritive value of various types of green fodder, hay, and silages for sheep. To combat the diseases that plague livestock, the *animal health* programme will produce vaccines for major animal diseases, develop monoclonal antibody technology, improve knowledge of the immune system of buffalo, and find control measures for Hydropericardium in poultry.

Work on *sheep and goats* will emphasize improving the hardiness and productivity through crossbreeding and developing improved methods of feeding and management. *Fisheries* work will stress greater output from reservoirs, artificial propagation of carps, and marketing studies.

The *soil sciences* programme will emphasize soil-plant nutrient interactions, which will improve fertilizer-use efficiency and reduce plant nutrient problems. Use of rhizobia, nitrogen-fixing azolla, and biofertilizers will reduce the need for chemical fertilizers. Screening of germplasm for various soil-related stresses will lead to varieties suitable for saline and arid areas.

Work on *soil and water conservation for Barani lands* will create a database covering soil, water, vegetation, and climate and the information will be used to develop packages of technology. The *irrigation systems and management* programme will develop guidelines for selection of suitable irrigation systems based on climate, land use, farm size, etc.; produce manuals for efficient irrigation practices; create an irrigation advisory service for Islamabad Capital Territory; and work with the private sector to introduce new irrigation technology. *Agro-meteorology* work will focus on developing a database suitable for formulating recommendations, gathering agro-meteorological information for the development of high-yielding cultivars, and providing agro-meteorological advice to farmers in the Islamabad Capital Territory.

In *remote sensing*, the emphasis will be on creating a fully functioning unit for digital analyses of satellite and airborne data and construction of simulation models.

To overcome the scarcity of fuelwood and timber, the *agro-forestry* unit will introduce tree species and screen them for their effects on adjoining crops and potential for fuelwood and fodder production, nitrogen fixation, and soil conservation.

To raise the productivity of Pakistan's vast range area, the *forage and pasture* unit will evaluate local and exotic species of grasses, legumes, forbs, shrubs, and trees, and develop technology for the most promising strains. In addition seed of selected species will be multiplied.

The *apiculture* programme will develop improved management methods including methods of harvesting royal jelly, propolis, pollen, bee venom, and wax. Higher yielding honey plants will be introduced. The *sericulture* programme will develop methods for getting four or five crops a

year from imported or local silkworm seed and will develop more productive mulberry cultivation practises.

Agricultural economics will stress analysis of alternative technologies to help farmers choose more efficient options and to improve recommendations for use of purchased inputs and measures to control soil erosion, waterlogging, and salinity. Analyses of import substitution and research impact will help planners.

The *Farm Machinery Institute* will focus on development of harvesting and planting machines for cereals and oilseeds, equipment for bulk handling and storage of grains, and the installation of projected agriculture structures and development of milking machines for buffaloes.

Farming systems research will raise cropping intensity and increase incomes in barani areas by introducing oilseed crops and grain legumes. Improved health and better fodder production will improve the reproductive performance of sheep and goats. Farming systems research will become institutionalized at provincial research units.

NARC has four special research programmes. The *national coordinated research programmes* bring together federal and provincial organisations in studies on commodities and on topics such as agro-forestry and animal nutrition. *International collaborative research programmes* are undertaken with a broad range of international institutions and bilateral programmes. The *Barani Agricultural Research and Development Project* (BARD) involves NARC and provincial institutes in the development and on-farm testing of improved technologies for barani areas. The *food technology* programme addresses food and nutrition problems. It will compile data on the nutritional quality and consumer acceptance of important crops, analyse the effects of storage on nutritional quality, evaluate diets in different zones, and develop methods to improve the shelf life of bread and to substitute other commodities for a portion of the wheat in bread, while raising the nutritive value.

Research Management

The current organisation of PARC is a product of fast growth. Changes have been recommended that would clarify lines of responsibility and improve the grouping of related research units. Among the major recommendations are that NARC should redefine its mandate, that NARC should operate under PARC guidelines, but without direct operating control by PARC, that posts for two deputy directors general—one for research and one for administration—should be created, that the post of coordinators of national coordinated programmes should be separate from the NARC post of principal investigator, that NARC institutes should be renamed departments, and that training for all levels of NARC staff should be strengthened.

The technical management of projects is done in the context of goals and objectives that have been established for 10 subject-matter areas to which different programmes are linked. There are 51 programmes currently being executed. Technical working groups consisting of qualified scientists screen proposed projects to ensure that they fit NARC objectives and are not duplicative or wasteful. Large projects must be approved by PARC and the Ministry of Food and Agriculture. Monitoring of on-going research is done according to established performance indicators.

The publication unit is responsible for issuing research reports and journals for scientists and popular use. Technology transfer involves improving the functioning of agricultural extension, training institutions, research-extension-farmer-linkages, and improving strategies for information delivery. The Extension Activity District, Islamabad, links NARC and farmers of the area in efforts to improve local crop and animal production, soil conservation, range management, and afforestation.

Support Services

Audio visual communication contributes to the dissemination of information. It produces audio-visual materials and provides training and guidance to scientists and research institutions.

Library services and documentation maintains a collection of books, journals, and microfilms. It serves as the link to AGRIS and CARIS, and implements CRIS—Pakistan's current research information system.

The laboratory equipment and maintenance unit is responsible for maintaining and repairing advanced laboratory equipment. It will extend it services to provincial institutions.

The computer and statistical services unit enhances the quality of research conducted at NARC by improving experimental design, testing statistical software, and providing training in biometrical techniques.

The plant introduction centre is the focal point of incoming and outgoing germplasm, organising plant collecting expeditions, and storing germplasm.

The National Herbarium maintains a collections of 75,000 plant type specimens.

The Training Institute organises lectures, training courses, symposia and international linkages for scientists, university teachers, extension workers, and farmers.

Postgraduate Capability

Upgrading of the present NARC training facilities to academy level has been proposed. Post-graduate training would prepare scientists to assume responsible position in research and management.

1
Introduction: Agriculture, Research, and NARC

BACKGROUND

Agriculture in the Economy of Pakistan

Forty years ago, agriculture was the dominant sector of the economy, contributing 53% of the gross domestic product. As the manufacturing, construction, and services sectors have grown, agriculture's share in the GDP has fallen considerably. Still, agriculture remains the largest single contributor to the GDP at close to 26%. Average agricultural growth has been faster than the rate of increase in population. In real terms, agriculture's contribution to the GDP may be greater, since domestic prices for agricultural outputs are distorted by a pricing policy which generally favors consumer. The agricultural sector employs 54% of the labor force and accounts for about three-fourth of the total foreign exchange earnings from exports. The sector supplies many of the major industries with raw materials and consumes 33% of the industrial finished goods. In terms of contribution to national income, employment, markets for industry, and supply of raw materials or products for export, agriculture remains the foundation of Pakistan's economy.

Since 1955, six 5-year plans have been completed. The shifting focus of the plans has led to an increase in the output of some commodities while setbacks occurred in others. The results of the sixth plan are shown in Table 1. To sum up, between 1960 and 1985, the average annual growth rate of agricultural value added has been 3.6%. But growth has been uneven due to weather conditions, periods of rapid technical change, and the pattern of pricing and other policy shifts (Table 2). Until 1977 the crop sector outperformed the livestock sector. Since then, however, the latter has shown considerable dynamism, particularly due to the rapid modernization of the poultry industry and increasing investment in milk animals.

The early 1960's were characterized by a rapid increase in the number of private and public tubewells. The introduction of high yielding varieties, coupled with the increased water availability, expanded use of fertilizer, and more appropriate price policies, brought about significant success in wheat and rice production. This technology refuted pessimistic forecasts and compensated for the unfavorable effects of the suspension of food aid in 1965.

Since 1970, however, increase in inputs—fertilizer, land, water, capital, and labor—has been the principal source of the growth rather than technical change. The increased water availability from tubewells and from the Mangla and Tarbela dams was an important factor leading to the greater use of purchased inputs, but it also affected cropped area. Table 3 shows the area expansion disaggregated into changes in net sown area and changes in double-cropped area. Until

1970, the total cropped area grew slowly and was dominated by increases in the net sown area. The index of crop intensity, which was 1.12 in 1960s, stood virtually unchanged at 1.15 in 1970. By 1980, however, the crop intensity index was 1.25, showing that a substantial increase in the double cropped area was the major contributor to changes in the total cropped area in this period.

Table 1. **Crop output targets and achievements for the Sixth Five-Year Plan** (Million tonnes)

Crop	Target	Achievements			
	1987/88	1983/84	1984/85	1985/86	1986/87
Wheat	15.50	10.88	11.70	13.92	12.95
Rice	4.20	3.34	3.32	2.92	3.49
Maize	1.38	1.01	1.03	1.01	1.11
Others	0.72	0.62	0.65	0.61	0.59
Cotton (lint)	1.03	0.50	1.01	1.22	1.32
Sugarcane	40.94	34.29	32.14	27.86	29.93
Tobacco	0.10	0.08	0.09	0.08	0.08
Oilseeds (excl. cottonseed)	0.79	0.33	0.33	0.35	0.39
Pulses	0.79	0.71	0.73	0.80	0.82
Fruits	3.59	3.27	3.44	3.50	3.64

Source: Planning Division, Government of Pakistan.

Table 2. **Average annual growth rate in agricultural production (At constant factor cost)** (Percent p.a)

	1960-65	1965-70	1970-77	1977-85	1960-85
GNP	6.8	6.8	5.2	6.4	6.2
Agriculture	3.8	6.3	1.7	3.7	3.6
Major Crops	4.7	9.1	0.9	3.5	4.0
Minor Crops	4.8	3.8	4.6	2.8	4.0
Livestock	1.9	2.0	2.4	4.4	2.8

Source: Derived from Pakistan Economic Survey, various years.

Table 3. **Additions to cropped area between 1960 and 1985** (Million hectares)

	Net sown area	Double-cropped area	Total cropped area
1960-65	0.66	0.02	0.68
1965-70	0.51	0.57	1.08
1970-75	0.62	0.78	1.40
1975-80	0.35	0.96	1.31
1980-85	0.13	0.63	0.76

Source:Derived from Pakistan Economic Survey, 1986/87.

The provincial pattern of growth in crop values between 1960 and 1980 is shown in Table 4. Agricultural growth has been most rapid in Sind and Baluchistan. But change in the share of the

gross crop value between the provinces over this period is more significant. The share of Sind increased from 19% to 25%, while that of the Punjab decreased from 68% to 63%. This change

Table 4. **Share and growth of gross crop value by province**

	Baluchistan	NWFP	Sind	Punjab
Share of gross crop value (%)				
1959-60	1.7	10.7	19.2	68.4
1970-80	3.3	9.0	25.1	62.6
Annual growth of gross crop value (%)				
1960-65	19.9	7.8	7.7	5.0
1965-70	7.2	2.2	7.3	7.1
1970-75	2.7	3.7	4.7	2.2
1975-80	5.2	2.6	5.5	3.5
1960-80	8.5	4.0	6.3	4.5

Source: Derived from Agricultural Statistics of Pakistan, various years.

was not due to only the increased adoption of the modern varieties over a greater area in Sind, but also to the larger share of high-value crops such as IRRI rice, sugarcane, and fruits produced in Sind.

Despite its impressive performance, the agriculture sector has still to fulfill its promise. Average yields per hectare of most crops are substantially below the perceived potential and yields of the progressive farmers, and also well below the average yields in more advanced economies of Asia, America, Europe, and Oceania. The true potential of the majority of farmers, caught in a web of structural and institutional dependencies, has yet to be realized.

Constraints to Agricultural Research and Development

Although the production of various agricultural commodities has increased over the years, there are number of serious biological, economic, social, and research and development constraints. Some of the prominent constraints in agricultural research and development are identified below.

Agricultural Research Constraints. The constraints to agricultural research are not only difficult to define they often are complex and not easily perceived. It can be argued that research in Pakistan is hindered by:

1. Inadequate conceptual clarity in determining agricultural research priorities.
2. Inadequate numbers, insufficient quality, and disciplinary imbalances of professional scientific staff across the country, and inter-regional as well as inter-institutional imbalances.
3. Inadequate motivation and incentive for scientists and insufficient recognition of quality research.
4. A research environment marred by socio-political weaknesses or immaturities.
5. Inadequate allocation or availability of resources for research scientists.
6. Critically inadequate maintenance and repair facilities for laboratory equipment within the national agricultural research system

7. Inadequate opportunities for national and international professional interactions amongst research scientists.
8. Historically weak or non-existent research-education-extension linkage and interactions resulting in little or no feedback and interaction with the farmer or end user.
9. Inadequate coordination and positive interactions amongst research institutions.
10. Slow development of a scientific research culture with consequential mistrust amongst research scientists which discourages sharing of knowledge and expertise, team work, and integration of research across disciplines or subsectors of agriculture.
11. Lack of recognition for ecology as an important discipline for agricultural research resulting in imbalance in physical, biological, and farming system dimensions with ill-defined agro-ecological zones or poorly integrated land use research.
12. Imbalance amongst long-term basic or fundamental research, short-term applied or adaptive research, and operational research.
13. Inadequate planning, coordination, programme definition, programme implementation, research monitoring, and research evaluation.
14. The near lack of research on the impact of research in objective, scientific, and economic terms.
15. Lack of acceptable quantitative models to determine intersectoral or intrasectoral agricultural research priorities.
16. The "personality cult" problem and individual subjectivities, which project scientist leaders rather than science or working scientists—an antithesis of science, research, or institutionalization of research systems.

Development Constraints

1. Rapid population growth, about 3% per annum, wipes out the benefits that should have been forthcoming from sustained investment in agricultural research and development. Pakistan's population is at present 100 million and even with optimistic assumptions of a declining growth rate, the population is projected to be about 136 million in the year 2000.
2. A low ratio of cultivated land to population—about 0.59 acre per capita.
3. Periodic floods and droughts.
4. Widespread prevalence of insect pests and diseases of plants.
5. Continued deterioration of the vast rangelands and arid/semi-arid tracts.
6. Small forest areas, which are insufficient to meet the normal requirements for timber, fuelwood, and other forest products.
7. Inability of the common man to pay prices of milk and meat commensurate with the cost of production on commercial scale, resulting in economically non-viable dairy and meat industries.
8. Lack of accurate information about the potential commercial production of relevant parts of the ocean and production of basic organic formations under specific conditions of sunshine, temperature, nutrients, and oxygen supply to ensure optimum output of fisheries.
9. Absence of site-specific packages of technology for the important agricultural commodities in various agro-ecological zones, especially rainfed areas.

10. Lack of a well-organized marketing system for the maximum benefit to the producers. Lack of a well-organized, closely coordinated, and properly integrated agricultural research system.

Agricultural Potential

Pakistan has large areas of fertile soils, suitable topography, favorable climatic conditions, and water wealth harnessed into a well-organized system that permits the production of a variety of food, feed, and fibre crops (Fig. 1). The Indus Basin is one of the world's largest natural resources, capable of producing about 100 million tonnes of foodgrains annually, but it barely produces a third of its potential.

The geographic area of the country is 79.6 million hectares, of which, in 1982-83, the cultivable area was 31.3 million hectares, but only 20.4 million hectares was actually cultivated. A considerable part of the remaining 10.9 million hectare could be developed for cultivation, if additional irrigation water becomes available.

The national average yields of major crops are far below the demonstrated production potentials. There is a wide gap (50-80%) in yields obtained at experiment stations using a complete package of improved technology and that of average farmers using out-moded traditional farming methods.

Pakistan is the home of some of the finest breeds of livestock, well-adapted to tropical and sub-tropical conditions. There is considerable scope for improving production per animal unit both through intensive selection and crossing with suitable improved exotic breeds.

The country has vast inland and marine fisheries resources. Breeding and introduction of fast-growing species, improved mechanized fishing crafts, provision of quick transportation, and more efficient storage facilities would provide enormous scope for further development.

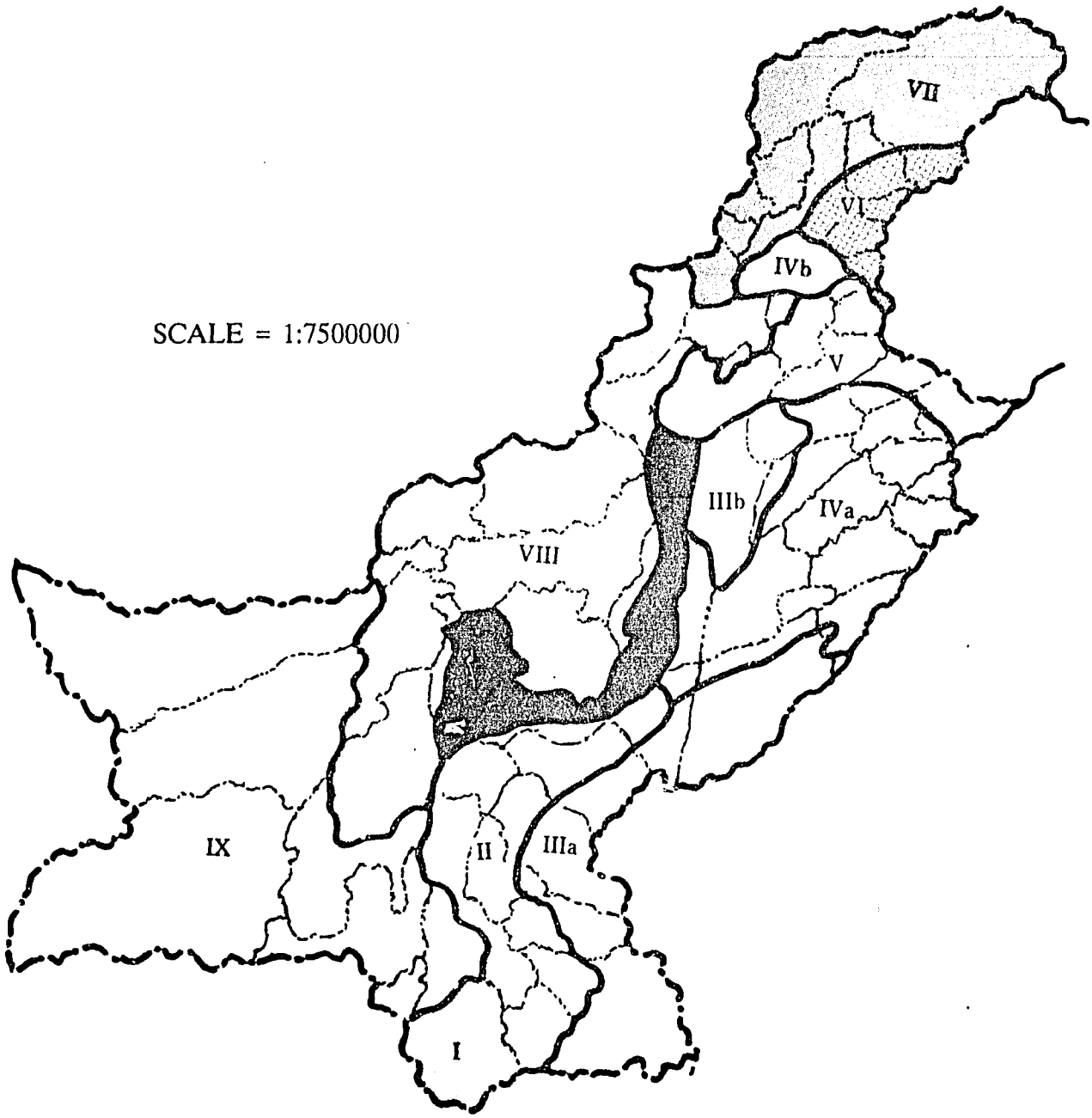
However, despite the potential, the country is not producing enough of some commodities to meet even the basic food needs of the population. The per capita availability of protein in Pakistan, especially of animal origin, is one of the lowest in the world. The chronic shortages of essential agricultural commodities like edible oil, dairy products, and timber, have resulted in importation at huge cost, which not only severely strains the limited foreign exchange resources of the country, but also hampers its overall economic development.

Role of Agricultural Research

The Sixth Five-Year-Plan focused on attaining greater self-sufficiency in agriculture. The major components of this strategy were diversification of crops, strengthening production and distribution, adoption of better agronomic practices, modernization of agriculture, and increasing productivity (especially of small farmers) to create exportable surpluses. There were various references in the sixth plan to the role of agricultural research. It was recognized that greater production must come from better yields (vertical improvement). The major thrust of the sixth plan continued to be control of waterlogging and salinity and enhancing water availability at the farm gate, with research needs to be expanded accordingly.

In the livestock sector, it was proposed that measures be taken to improve research facilities and develop strong connections between extension and research so that results reach the farmers. The need for efforts on feeding and nutrition research was emphasized. In the forestry sector, improved technologies for nursery planting, protection, and thinning operations were focal points. In the fishing sector, the development and application of new technology was specifically mentioned.

The sixth plan failed to achieve the anticipated diversification towards high-value crops and production of non-traditional oilseeds. Although, fruit production increased, markets were not



I	Indus Delta	II	Southern Irrigated Plain	III	Sandy Desert (a & b)
IV	Northern Irrigated Plain (a & b)	V	Barani Lands	VI	Wet Mountains
VII	Northern Dry Mountains	VIII	Western Dry Mountains	IX	Dry Western Plateau
X	Sulaiman Piedmont				

VII VI IVb V IVa IIIb VIII X II IIIa I IX

FIG 1. PAKISTAN AGRO-ECOLOGICAL REGIONS

explored abroad and post-harvest facilities and technologies remained inadequate. The production of non-traditional oilseeds is expected to be only 60,000 tonnes in 1987-88 against a plan target of 350,000 tonnes. The reason was that research, extension, and developmental activities were not vigorously implemented.

The recommendations of the National Commission on Agriculture (NCA) set up by the Government in 1986 formed an integral part of the seventh plan strategy. The report of the NCA submitted in April 1988 proposed a broad-ranging strategy for the period 1988-2000 and aimed at consolidating what has already been achieved in agriculture, particularly self-sufficiency in basic commodities, and further improving the productivity of crops, livestock, fisheries, and forestry. A growth rate of 4.7% per year was envisaged for the agriculture sector during the seventh plan.

In the seventh plan once again it has been fully recognized that research, particularly in the evolution of high-yielding varieties, plays an important role in the development of agriculture. No institute can be successful unless research in different disciplines of agriculture is organized and strengthened at various levels in an integrated manner. During the seventh plan research activities will be organized in the following manner:

- Basic and strategic research will be carried on in national institutes like NARC. Applied research involving development and testing of new varieties will be conducted at the provincial research institutes.
- High-yielding and disease-resistant varieties of crops, especially oilseeds, pulses, rice, sugarcane, fruits, and vegetables will be evolved.
- Agronomic research will be undertaken to develop a package of management practices for different crops in order to maximize their productivity and fully exploit the potential of improved varieties.
- Research programmes will be undertaken to evolve improved production technologies and systems for less-favored environments such as rainfed, arid, high-altitude, and coastal areas.
- Federal and provincial cotton research institutes will be strengthened and research efforts will be oriented towards improving the quality of lint and raising yields.
- A national sugarcane research institute for the development and evolution of sugarcane varieties will be set up at Sujawal. There is also need for a sugar technology institute, preferably established by the sugar industry to conduct research on milling, processing, and utilization of sugar by-products.
- Genetic improvement of livestock will be undertaken through crossbreeding, artificial insemination, and embryo transfer technology. However, the major thrust in livestock production will be on closing the nutrition gap by promoting supplementary feeding with constituted feeds.
- Theoretical, basic, and applied research will be so integrated that PARC, agricultural universities, and the provincial research institutes complement each other in research efforts.

The research programme for the seventh plan will also include development of an efficient national agricultural research service capable of exploiting and improving the potential for agricultural development and productivity. This will be achieved by developing and strengthening provincial research capability and consolidating efforts at PARC at the federal level. Emphasis will be placed on integrating all possible federal and provincial research activities.

Return to Investment in Agricultural Research

Level of Investment. Increased investment in agricultural research can be justified by the high rate of return that society receives. Modern agriculture throughout the world is based on the application of improved technology to the growing of crops and the raising of animals. To feed the population and to trade efficiently with the rest of the world, Pakistan must continue to improve the performance of its crop production and livestock sectors. This can only be done by adequate research into the problems of agricultural producers and the translation of this research into improved farm practices.

The level of investment in agricultural research in Pakistan is relatively low. In 1983-84, it was 0.21% of GDP. The programme set out in the NARP seeks to raise the investment by 50% in real terms over a 15-year period—to only 0.3% of GDP.

Impact of Research. Over the last 20 years, research has brought about a vast change in Pakistan agriculture. Since mid-1960s, the area of wheat under high yielding varieties has increased to 86% of the total area sown. Furthermore, within this transformation of agriculture, there has been a complete turnover of the new varieties introduced. In 1973-74, the semi-dwarf Mexi-Pak wheat was planted on 56% of the sown area. Since then, varieties introduced by Pakistani scientists have taken over and they now cover nearly 80% of the sown area.

Much progress has been made in other crops too. The area under IRRI rice has risen to 46% of the area in face of strong competition from Basmati rice, which is more popular and higher priced. Improved varieties of cotton are grown throughout nearly all of Pakistan. Out of 2.26 million hectares in cotton in 1982-83, Pak-Upland cotton was planted on 2.10 million hectares. In the case of maize, new varieties selected within Pakistan are grown on over 50% of the area planted. Yet the national results of many research programmes are not as spectacular as could be wished. Wheat has shown a steady yield increase of 3% per year through the 1970s and into the 1980s. But average yields of rice, cotton, maize, and sugarcane have only increased marginally in the same period.

In brief, the position of the Pakistan agriculture would have been much worse if the new high yielding, disease-resistant varieties had not been introduced. Research, therefore, has the important role of anticipating and countering any unfavourable changes in the biological status of Pakistan agriculture. Breeding and selection of new varieties must be a continuous process to remain ahead of the threat of famine that disease and pests impose. At the same time, farm level productivity per unit area must be enhanced by all possible means including extension, adequate and timely supplies of inputs, and appropriate incentives.

Another demonstration of improvement in crop yields comes from the constraints research programme conducted in recent years. These trials on farmers' fields were set out to show the contrast between farmer practices and recommended practices. A typical demonstration would compare the farmer's levels of fertilizer, his weeding practices, and the traditional variety he has always grown with best recommended practices.

The potential gains to society from scientific investigation of new varieties can be obtained from the yield constraints data. Since the layout of these farmer trials separates the effect of fertilizer, variety, and weeding, it is possible to measure the yield effect due to variety (research) alone. The recent results of a survey of constraints data by J.G. Nagy for wheat in Pakistan indicates that the yield responses is much greater for irrigated land than for unirrigated land. Within each types of land, the yield effect due to variety depends upon the other inputs with which it is combined. On the average, however this study shows that improved varieties give an 18% yield gain in unirrigated areas and a 46% gain in irrigated areas.

The gains from research can be translated into data on the national return on the investment in agricultural research. For wheat research, the total research expenditure over the period since the introduction of Mexi-Pak varieties has to be calculated. The question is then asked: does the above yield increment of wheat due to varietal improvement alone justify the historic research expenditure that has gone into it? This is a complicated mathematical question to answer, but acceptable methods of analysis are available which compare the value of extra wheat produced (from research effort) with the total cost to society for carrying out that research. This ratio is called the internal rate of return. It measures the social profit to the nation as a whole from the investment in research. Individuals are not shown as gainers, only society as a whole, as it has more food than it would otherwise have had.

Rate of Return. J.G. Nagy has investigated the rate of return for both wheat and maize in Pakistan. From his consideration of the cumulative costs of research and extension on wheat in the provinces to the present, he estimated that the nation has received a 58% rate of return on its investment in wheat research. Following the same approach for maize, he estimated that there has been a rate of return of 19% from all science investment in maize research.

The above results indicate that the people of Pakistan have benefited considerably from previous research in agriculture. Since further yield increases are possible and research is continuing on new varieties, disease resistance, pest control, etc., the potential for a high investment return in the future is better than the investment in the past. These analyses under-pin the projections made in the NARP. Agricultural scientists are confident that if agricultural research funding is raised to 0.3% of GDP by the year 2000, the nation will get a very adequate return in the form of cheaper food and greater exports.

Evolution of Agricultural Research in Pakistan

The Pakistan Agricultural Research Council (PARC) has its origin in the Imperial (later Indian) Council of Agricultural Research (ICAR), which was started in undivided India, as early as 1929. ICAR, which established a number of world-famous central research institutions in India, went through several transformations in its scope and organization. Unfortunately, all the central research institutes of the ICAR were left in India at the time of partition. The only research establishments in Pakistan at independence were the provincial research stations, which had been established in undivided India in all provinces to undertake applied and adaptive research on local agricultural commodities. Consequently, in Pakistan the development of central research institutions in major agro-ecological regions and for important commodities was delayed due to lack of a determined effort and financial resources.

There has never been doubt about the urgent need for such central research organizations. The issue was discussed several times in the successive federal cabinets which endorsed the importance of developing a capability for advanced research at the federal level to support the rest of the system, but concrete steps were taken only recently. The Government of Pakistan invited high level teams of U.S. scientists to review the agricultural research system along with Pakistani colleagues and suggest measures for radical improvements. The joint Pak-US agricultural research teams undertook extensive reviews in 1968 and 1973, and their recommendations were thoroughly discussed at the provincial level and approved by the Government.

Since 1978, to remove the impediments to the rapid development of PARC and the national agricultural research system, the Government has made several important decisions which have resulted in a significant improvement of facilities for agricultural research in the country:

1978

- The Cabinet decided that "The Agricultural Research Council should be an

autonomous body at the Federal level and should work in close coordination with the Ministry of Food and Agriculture, the provincial agricultural departments and agricultural research institutes, and the agricultural universities."

- The Agricultural Research Council was constituted with a broad membership: full-time working scientists from the provinces, heads of research institutes, vice chancellors of agricultural universities, and progressive farmers. A sub-committee of the council designated as executive board, comprising the chairman and full-time members, was set up to assist the council in the management of its affairs.
- A cabinet committee was set up to suggest measures for implementing short-term and long-term steps recommended by the chairman, PARC, for boosting wheat production and for overall strengthening of the agricultural research system.

1979

- The cabinet committee proposed revision of Agricultural Produce Cess Act on the pattern of WAPDA to make PARC fully autonomous and to transfer all the employees of the attached department of Agricultural Research Council en bloc to the autonomous PARC.
- A joint World Bank, USAID, and CIDA mission, led by Sir Charles Pereira visited Pakistan at the request of Government of Pakistan. The mission visited 73 agricultural institutions in the country to conduct an in-depth review of the agricultural research sub-sector. Its report was submitted in May 1980.

1980

- A World Bank mission visited Pakistan to appraise the Pakistan Agricultural Research Development Project (PARDP), which was formulated on the basis of the recommendations of the Pereira mission.

1981

- Anticipatory approval of the project was given by ECNEC and the credit agreement was negotiated with the World Bank.
- Agreement for an IDA credit of US $24 million for the PARDP was signed with the World Bank with the following major components:
  1. Provision of PARC headquarters building.
  2. Completion of NARC with expanded facilities for animal sciences, library services, instrument repair, biometrics, and computing.
  3. Strengthening of the plant introduction, cereal and other diseases, and oilseeds and agricultural engineering programmes.
  4. Provision of financial support to PARC to increase country-wide grant support to various institutions.
  5. Support for 65 Ph.D., 76 M.Sc., and 44 person-years of short-term training.
  6. Provision of 24.4 person-years of long- and short-term technical assistance.
  7. Support for 245 person-months of services from short-term advisers.
  8. Recruitment of 264 professional and 356 supporting staff.
- Pakistan Agricultural Research Council Ordinance, 1981, promulgated. The main features include:

  1. PARC was made fully autonomous.
  2. A Board of Governors was formed as the policy-making body of the council.
  3. The functions of PARC were redefined as being to undertake, aid, promote, and coordinate agricultural research, arrange the expeditious utilization of research results, establish research institutions, arrange training of scientific

personnel, maintain a reference and research library, and generate, acquire, and disseminate information relating to agriculture.

4. The executive board was renamed the executive committee to work as the principal administrative body of the council.
5. All civil servants of the attached department were transferred to PARC (autonomous), except non-optees.
6. Cess collection was discontinued: instead Government agreed to provide an annual grant-in-aid.

NARC Mandate

NARC is primarily intended to undertake basic and strategic research on complex agricultural problems which require sophisticated laboratory facilities. In addition NARC has established a number of research support facilities for the agricultural scientists in the country. These facilities, include a center for plant introduction, a gene bank, computer-based data processing, a well-maintained agricultural library, a documentation center, and a centralized facility for instrumentation and repair of scientific equipment.

Important specific aims of NARC are to:

- Conduct research in areas of national importance which cannot adequately be undertaken elsewhere.
- Develop the national plant introduction and genetic resources conservation programme and promote the documentation, distribution, and use of a wide range of plant and animal germplasm.
- Provide laboratory facilities for basic and applied research in selected aspects of plant and animal sciences, food technology, soil sciences, water resources use, and farm mechanization.
- Support provincial institutions by conducting fundamental research and by providing facilities for all scientists to solve complex problems for which their institutions may not be adequately equipped.
- Collaborate with relevant national and international research organizations to develop research excellence and to generate useful technology.
- Assist research institutions in assessment of research needs, development of programme, and taking policy action.
- Emphasize a farming systems approach by synthesizing production technology for various agricultural commodities into integrated systems that maximise productivity of farm resources, particularly for barani areas.
- Develop a training unit to conduct short-term training courses and to hold technical conferences and seminars for the national staff engaged in agricultural research, planning, and development.
- Develop a reference library, an agricultural research database, and a centralized information service that encourages cooperation and communication among national, regional, and international institutions and provides up-to-date research information to all scientists and extension specialists in the country.
- Define alternative research strategies and assess their implications for food and fibre production, food production processes, technological change in agriculture, low-income groups, international food trade, and food security.
- Publish and distribute the results obtained from research programmes and promote the immediate and efficient application of results emerging from research.

Research objectives

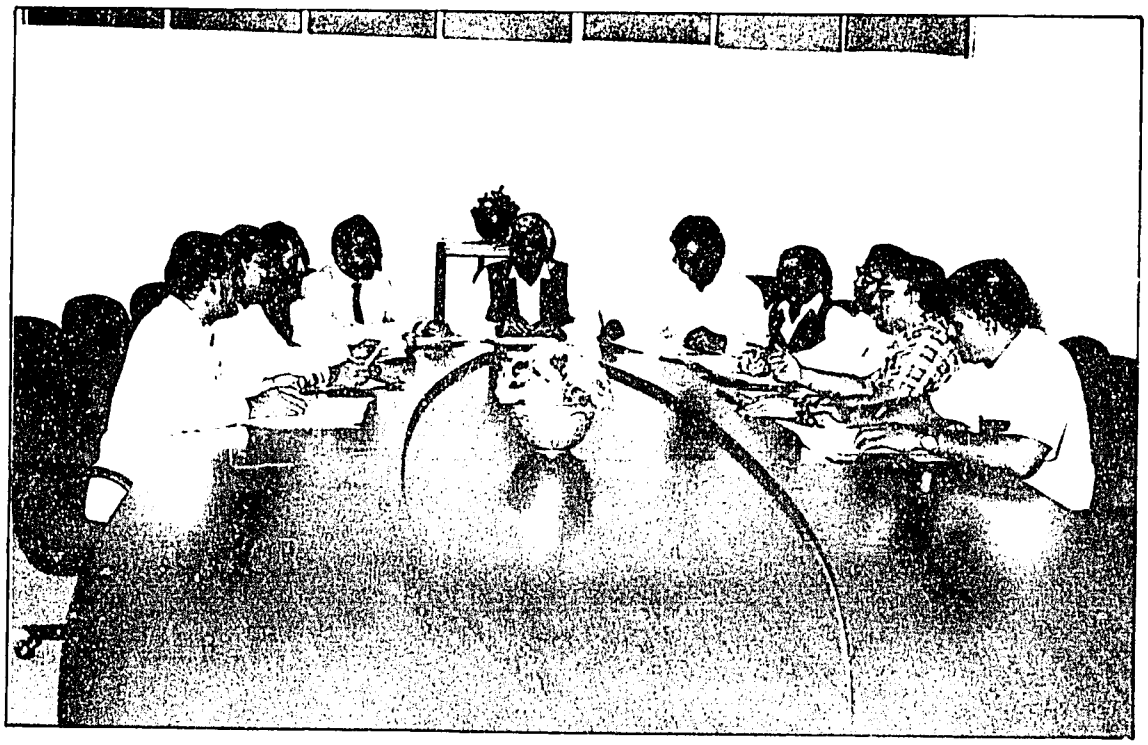
- Increase productivity and quality of priority crops—oilseeds, cereals, pulses, and vegetables—to improve farm income with emphasis on small farmers.
- Introduce, adapt, and generate improved technology for barani areas on an integrated land use basis.
- Improve processing and minimize losses of agricultural products for human consumption.
- Establish economically sound technology to improve livestock productivity and net farm income.
- Develop better farming systems technology which optimizes resource management and yield packages for ready transfer.
- Exploit natural resources to provide food and feed for humans and livestock.

Research thrusts

- Develop basic plant growth knowledge and improved cultural practices, particularly to maximize efficiency from fertilizers and agro-chemicals.
- Generate knowledge on the basic biology of weeds, insects, and pathogens to reduce pest losses and develop low-cost integrated pest control practices.
- Select improved germplasm of priority crops and symbiotic organisms.
- Improve techniques to assess and predict water available to the plant and the plant's ability to utilize soil moisture through improved agronomic and mechanized technology.
- Generate and package for farmers' adoption improved cost-effective barani systems, including agro-forestry, which support sound long-term land use.
- Develop means to minimize post-harvest losses caused by pests and spoilage, and improve processing of major food products and livestock feed.
- Identify the biological and biochemical mechanisms in plants and livestock and manipulate them to improve their usefulness.
- Improve livestock nutrition and feed efficiency to increase productivity and quality production.
- Develop appropriate selection and mating systems and characterize useful genetic and biochemical traits to assist farmer practices.
- Establish preventive and control measures to minimize livestock diseases, parasites, and toxicants.
- Develop technology and methodology to collect socio-economic and management data and provide for its analysis and interpretation to guide farming systems research.
- Develop improved farming systems which are biologically and socio-economically viable, including mechanization and the marketing of farm products.

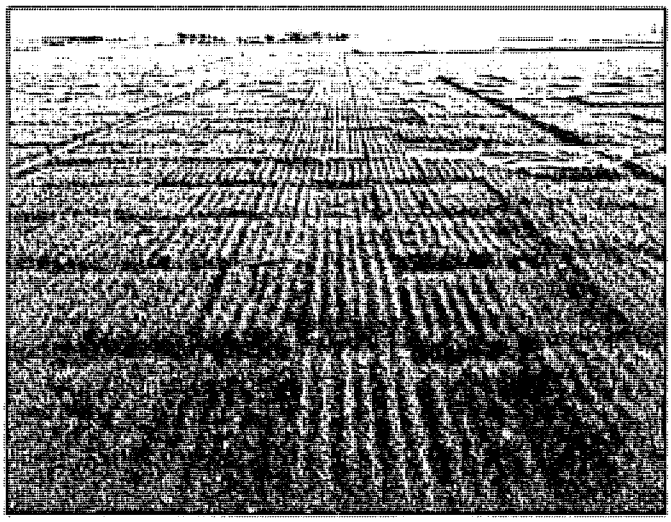
Support services objectives

- Strengthen the capacity of the national agricultural research system in conducting basic and applied research.
- Facilitate the flow and documentation of scientific and technical information.
- Develop quality training facilities and capability for national and international seminars, workshops and training courses.
- Accelerate the transfer of improved technology, methodology, and information to increase agricultural production and net farm income.

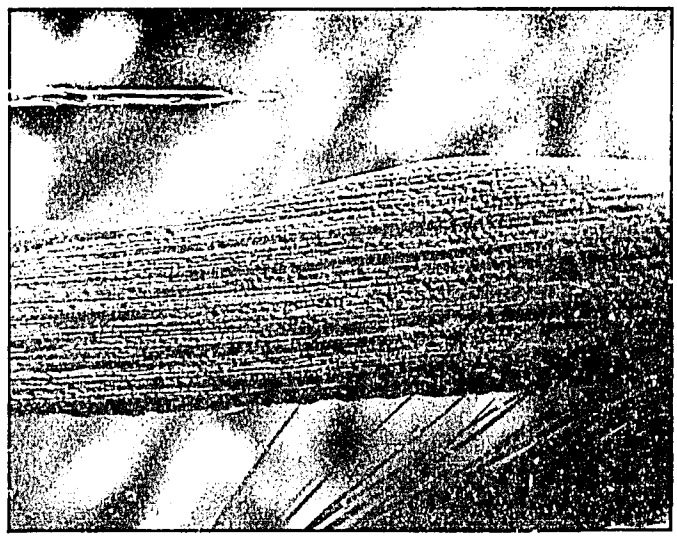


The NARC Management Board chaired by the Director General consists of research institute and support service directors. The board interprets policy, addresses important management issues and acts as an advisory body to the Director General, NARC.

In the development of the NARC Master Research Plan, the writing team was appointed to assist in analyzing pertinent data and to collaborate with the scientists, support staff and administration in preparing material for the Master Plan.

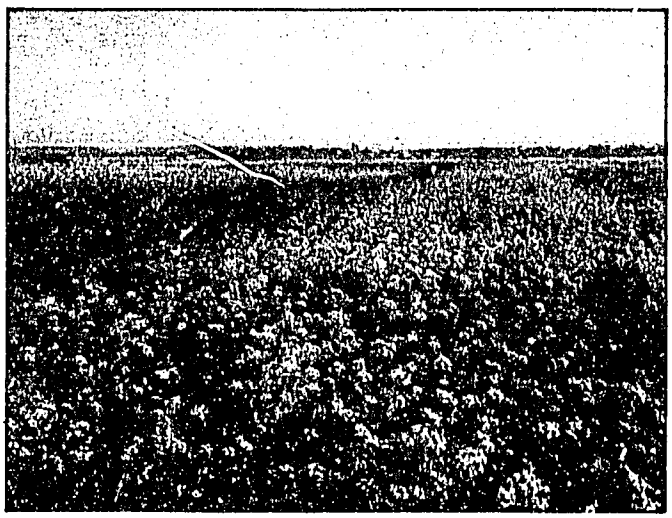


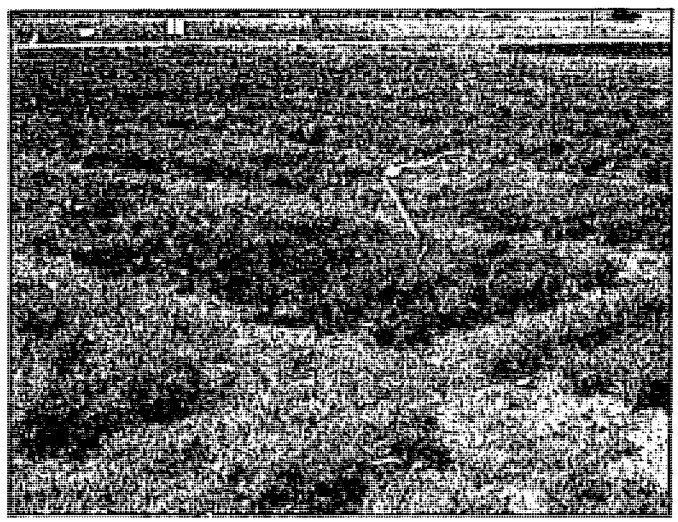
About 20,000 wheat germplasm entries obtained from local and international sources are being annually screened and evaluated at NARC, as well as supplied to the collaborating provincial institutions to develop high yielding wheat varieties



The identification of new races of rust and replacement of resistant varieties is a continuing NARC research activity conducted by pathologists in collaboration with plant breeders, and tested throughout the national research system.

Rape and mustard are among the most important oilseed crops in Pakistan. These crops also serve as a source of fodder. Scientists have developed new varieties and management practices for farmers to improve farming system productivity.





The NARC scientists have been successful in the identification of chickpea breeding materials resistant to Ascochyta blight, which causes colossal crop losses during epidemic periods.

NARC's Role in the National Agricultural Research System

Sustained agricultural research is necessary to expand agricultural production to meet the food needs of the growing population, as well as to provide raw materials for the country's agro industries. It has been well established that agricultural research is the best investment for increasing farm output and improving the national economy. Numerous empirical studies of the cost/benefit ratio of agricultural research have shown that the annual tangible and direct benefits have a minimum range of 40 to 60% (see below).

In Pakistan, all four provinces have established a large number of institutions and stations to meet their specific agricultural research needs. The activities of these institutions need to be coordinated at national level to make judicious use of personnel, money, and materials. Pakistan Agriculture Research Council is the only organization in the country with a mandate to coordinate agricultural research being carried out in the provincial and federal institutes and the universities (Figure 2). It can concentrate attention on national problems, undertake strategic research, promote research on farming systems not covered by the individual provincial institutes, and provide sophisticated support services to the provincial and other research institutes to facilitate their work. The establishment of the National Agricultural Research Center at Islamabad is thus one of the chartered functions of PARC.

NARC is the premier establishment for research in areas of national importance. Since, its inception, NARC has been fully engaged in meeting the challenge of bridging gaps in national agricultural research. NARC has excellent physical facilities experimental areas, laboratories, farm houses, germplasm bank, library, documentation center, auditorium, workshop, stores, hostels, cafeteria etc. In addition to the main complex, several institutes have been established: Plant Sciences Institute (PSI), Animal Sciences Institute (ASI), Farm Machinery Institute (FMI), and Training Research Institute.

Currently, PSI is working on the improvement of almost all major food and feed crops. NARC has also intensified research on efficient use of soil, fertilizer, and water resources; control of more important pests and diseases; basic and applied research in crop biochemistry and crop physiology; biotechnology in a few carefully chosen areas like tissue culture, and microbiology. More recently NARC has begun work on application of remote sensing techniques to obtain a better understanding of the problems of pests and diseases, soil health and moisture stress, and artificial rainmaking; and establishment of a legume inoculant production unit has been initiated.

ASI carries out several research programmes. Well-designed laboratories provide a proper environment for research in disciplines such as embryo transfer, reproductive physiology, dairy technology, animal nutrition, animal health, and fisheries. Facilities are also available for research into poultry and fish development.

FMI plays an important role in the mechanization of agriculture in Pakistan. The institute's prime objective is to design and develop appropriate farm machinery which can be locally manufactured. In fact the FMI supplies design and technical assistance to encourage local industry to produce appropriate farm implements.

The NARC training institute responds to personnel development requirements in agricultural research. The institute plans, designs, organizes, and implements training courses in response to various provincial and national needs. During 1983-87, 124 seminars, workshops, and training courses were conducted. There were over 3300 participants including scientists and extension workers from federal and provincial agricultural institutions and farmers.

Field testing technology is an important step of any research process. NARC has established a technology transfer unit (TTU) to extend NARC-developed agricultural technology to the

farmers in the Islamabad territory. Feedback from farmers helps to guide further experimentation and analysis. The TTU also arranges training courses and field demonstrations for farmers in the Islamabad area.

National Commission Report 1987

The National Commission on Agriculture is the latest in a series of commissions stretching back more than hundred years in the Indian sub-continent. This commission was announced by the former Prime Minister of Pakistan, Mr. Mohammed Khan Junejo, comprising eminent scientists, planners, administrators, and farmers. The summary of the terms of reference assigned to the commission are reproduced below:

1. Comprehensive review of the agriculture sector during the past 2 decades.
2. Propose measures for the improvement and modernization of the agricultural sector to achieve a sustained increase of 5% per annum in agricultural production during seventh plan (1988-93).
3. Examine agricultural potentials and propose optimum utilization.
4. Improve price support policies to improve returns to farmers and to establish competitive prices in the international markets.
5. Examine the agricultural institutional framework to improved research extension and teaching and their interaction. Also to explore prospects for post-harvest loss prevention, crop insurance, and cooperative movements.
6. Evaluate effectiveness of policies for the improvement of the economic condition of the small farmers.
7. Isolate immediate problems that might have inhibited the production of edible oils in the country.
8. Assess the manpower requirements in various disciplines of agriculture for the next 10 years.
9. Suggest measures for simplification of rules, regulations, and procedures applicable to agriculture sector.

The NCA report, comprising more than 650 pages, covers multidisciplinary aspects related to agriculture and emphasized over 100 points of importance to the agriculture development of the country. Listing the detailed recommendations of the commission are beyond the scope of this chapter. A committee has been recently set up by the Federal Ministry of Food and Agriculture to be responsible for the implementation of this report.

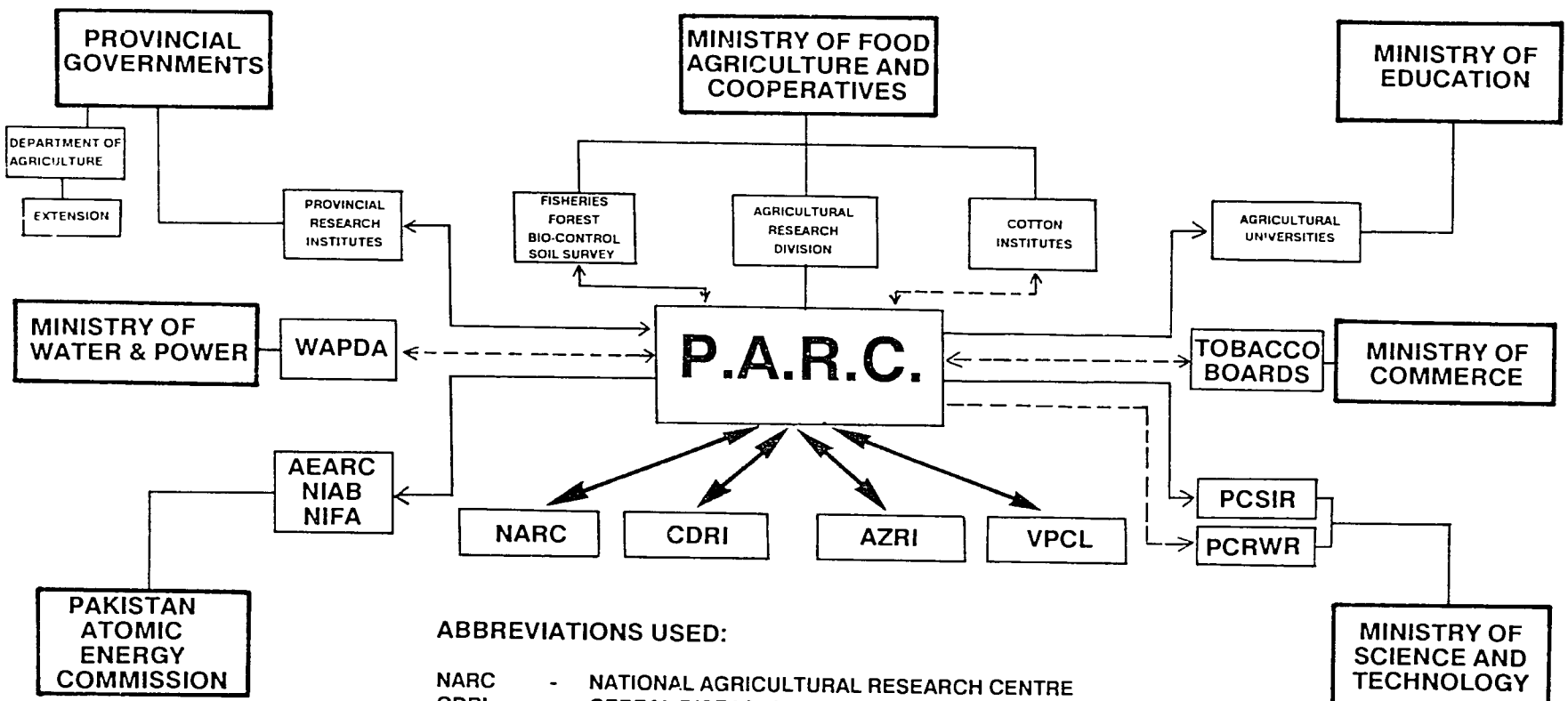
PRESENT STATUS OF AGRICULTURAL RESEARCH AT NARC

Research Funds

Until 1981, most of PARC research schemes were funded through cess funds. However, in the new ordinance, PARC has been given financial support by the Government as grant in aid in addition to PL-480 funds and funds from some other international agencies. PL-480 funds are almost exhausted. Only previously initiated projects will be supported with PL-480 funds.

Yearly budgetary allocations to NARC during the last 5 years are shown in Table 5. Almost 85% of the total budget (developmental and non-developmental) is consumed for salary and allowances including operational heads and only 15% is spent on active research. The annual research expenditure per scientist is 49,000 rupees (Table 6). There is no hard and fast rule to determine an optimal level of expenditure for research. In developed countries, 2 to 4% of GNP

Figure 2. THE FEDERAL AGRICULTURAL RESEARCH SYSTEM SHOWING INVOLVED MINISTRIES AND INSTITUTES WITH PARC LINKAGES TO FEDERAL AND PROVINCIAL INSTITUTES



ABBREVIATIONS USED:

NARC	-	NATIONAL AGRICULTURAL RESEARCH CENTRE
CDRI	-	CEREAL DISEASES RESEARCH INSTITUTE
AZRI	-	ARID ZONE RESEARCH INSTITUTE
VPCL	-	VERTEBRATE PEST CONTROL LABS.
WAPDA	-	WATER & POWER DEVELOPMENT AUTHORITY
NIAB	-	NUCLEAR INSTITUTE FOR AGRI. & BIOLOGY
PCSIR		PAKISTAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
PCRWR	-	PAKISTAN COUNCIL FOR RESEARCH IN WATER RESOURCES

LEGEND

STRONG LINKAGE

WEAK LINKAGE

INCIDENTAL LINKAGE

or even more is allocated for research. In contrast, developing countries as a group allocate 0.1 to 0.3% of GNP to research, which is very inadequate to promote scientific activities.

Table 5: **Annual budget of NARC** (Rs. in million)

Year	Staff cost	%	Capital	%	Operational	%	Total	%
1983-84	9.2	40	2.6	11	11.1	49	22.9	100
1984-85	10.0	37	3.9	15	13.0	48	26.9	100
1985-86	22.2	49	5.3	12	17.6	39	45.2	100
1986-87	23.3	55	3.3	7	16.1	38	42.6	100
1987-88	31.7	58	6.2	12	16.4	30	54.6	100

Source: PARC

Table 6. **Budget for scientific research (1987-88)** (Rs. in millions)

Head	Non-dev.	Developmental	Total
Budget for NARC	36.9	17.7	54.6
Support services	12.8	0.7	13.5
Scientific Prog., Salary, Allow., Rent, Construction, Provision	15.8	19.7	25.5
Net Budget for Research	8.2	7.3	15.6
No.of scientists	207	114	321
Research budget/scientist. (thousand Rs.)	40	64	49

Source: The Budget of 1987-88 (PARC). Finance Division, PARC Publication.

Instead of rapid increase in 1987-88 budget of NARC, there is a slight decline of about 2.2 million rupees (Table 7).

Table 7. **Sectoral allocation of NARC budget** (Rs. in Millions)

Unit/Head	1986-87 Revised Budget	1987-88 Budget
Total	48.5	46.3
General Administration	8.1	7.6
Plant Sciences Institute	17.6	17.0
Animal Sciences Institute	5.7	5.5
Central Labs.	1.8	1.7
Farm Machinery Institute	2.8	2.8
Crop Diseases Research Institute	2.0	1.8
Training Institute	0.6	0.5
Farm Operations & Services	1.8	1.7
Scientific Information Unit	2.5	2.2
Natural Resources Sector	2.7	2.6
Agri. Extension Services	0.8	0.7
Current Scientific Schemes at NARC	2.2	2.2
Agri. Extension Services (ICT)	-	3.1
Miscellaneous	2.5	3.0

Source: The Budget of 1987-88 (PARC) Finance Division. PARC Publication.

Research Staff

The need for a strong scientific base of agriculture has been acknowledged recently. Because scientific manpower had always been scarce in various disciplines of agriculture, there has been no revolutionary change in farm production. In the last decade, the total number of scientists engaged in agriculture research and teaching has almost doubled. However, there has been no significant increase in proportion of highly trained scientific staff (Table 8).

Table 8. **Qualifications of Pakistan's agricultural scientists engaged in agricultural research and teaching**

Qualification	1977-78		1983-84		1986-87	
	No.	%	No.	%	No.	%
Ph.D	233	8	299	9	459	9
M.Sc.	1405	50	2181	63	3139	63
B.Sc./DVM	1196	42	951	28	1352	28
Total	2834	100	3431	100	4950	100

Source: Report of the National Commission on Agriculture 1988.

Well-trained human resources in scientific research are among the most important prerequisites for meeting growing agricultural demands. Putting special emphasis on increasing trained manpower, PARC has launched a widespread multidisciplinary training programmes in the last 5 to 8 years. The result has been a small but appreciable increase in the total numbers of trained personnel at NARC in particular and around the country in general. However, NARC still has only 49 Ph.D scientists in seven major categories (Table 9). All major areas except crop production have an acute shortage of professional leadership.

Table 9. **Scientific manpower (agriculture sector) at NARC**

S.No. Sector	Qualification				
	Ph.D	M.Sc*	B.Sc**	Total	%
1. Crop Production	24	115	6	145	44
2. Crop Protection	10	38	2	50	15
3. Animal Sciences	8	30	9	47	14
4. Forestry and Natural Resources	5	19	8	32	10
5. Computer & Statistics/ Agriculture Extension	1	20	-	21	6
6. Agricultural Machinery	1	7	23	31	9
7. Scientific Information and Library	-	3	2	5	2
Total:	49	232	50	331	100

* Also include M.Phil. ** Includes B.Sc (Agri.); B.Sc (Eng.) & DVM. Source: PRMC, NARC.

Research Facilities and Amenities

The Pakistan Agricultural Research Council is responsible for providing scientific leadership to the nation's agricultural researchers through its centre of excellence, NARC, which has highly competent personnel and well-equipped laboratory, greenhouse, and field facilities. The NARC mandate is to supplement the provincial research centers. In other words, NARC research programmes are nationally coordinated with the provinces and aim to provide opportunities to

scientists to interact and conduct research on problems of national importance that have not been addressed or for which have not been achieved due to lack of facilities and resources. An appreciation of NARC research facilities can be gained through a description of its physical plant and the quality of equipment installed.

Physical Facilities. The National Agricultural Research Center has 440,579 square feet of covered area. The main complex covers 102,033 square feet and includes administration building, auditorium, library, central laboratories, training institute, hostels, and cafeteria.

The Crop Sciences Institute, covering 66,507 square feet, has offices for the commodity coordinators and their staff, crop processing buildings, farm input storages, workshop, and central stores. A portion of this building is old and has undergone renovations at various occasions. Construction of a new Crops Sciences Institute, approved under the World Bank project, is likely to begin in 1989.

The Farming Machinery Institute inaugurated in 1987 covers 24,190 square feet adjacent to the Crop Sciences Institute.

The Animal Sciences Institute has the largest covered area, 121,336 square feet, which includes old and new buildings with 40 residences for officers and staff.

NARC, located away from the city area, provides residences to a small number of employees. The center accommodates 33 officers and 80 other staff in their housing colonies. The area covered by these colonies is 65,711 and 49,540 square feet, respectively.

The field laboratories of the Barani Agricultural Research and Development Project cover 6,930 square feet.

The honeybee project has been strengthened in recent years. A separate block with a covered area 4,332 square feet has been marked for apiculture research.

NARC has scattered mettled and gravel roads 3050 meters long providing vehicles access to experimental plots and the institutes scattered around the 640 hectare center. In addition there are 3060 meters of irrigation canals and 1900 meters of drainage canals.

Future construction is planned for the audio-visual production unit, a new cafeteria, and an extension of the training institute to function as the National Academy of Agricultural Professionals (as approved by the National Commission on Agriculture).

Laboratories. Almost every programme related to basic or applied research has its own laboratory. However, the central laboratories has excellent facilities for various studies, and programmes collaborate with each other on multidisciplinary issues. In addition to basic laboratory accessories, the central laboratory complex has 36 sophisticated instruments needed for advanced analytical work (Annex I).

NARC Library. The NARC library caters to the needs of agricultural scientists of various government, semi-government, and educational institutes, and departments. The library has two professional staff members and a seven-person support staff. More than 25,000 items consisting of books, monographs, periodicals, theses, microforms and audio-visual materials are housed in the library. The library collection has grown by a factor of 10 since 1982. The library is equipped with UBIX 3300 MR, Microforms reader computer terminal, 35 mm and 16 mm projectors, overhead projectors, epidiascope, tape recorders, transparency makers, and a microform unit.

The library plans to computerize its complete bibliographic data to permit quick retrieval of information. In addition this will allow compilation of union list of journals and a union catalogue of agricultural and allied libraries of Pakistan.

Research Support Services

As a center of excellence, NARC has advanced analytical tools and knowledgeable technical personnel which serve the local and national agricultural research system.

Laboratory Equipment Maintenance and Repair Unit. The laboratory equipment maintenance and repair unit at NARC provides technical support services to research by taking the responsibility for installation, commissioning, repair and maintenance of all laboratory equipments and instruments at NARC Complex, PARC out-station laboratories, etc. Assistance to provincial organization is also sometimes furnished. The unit is headed by a deputy director who is a biochemist by training, and has 10 technically trained staff members. This unit ensures the optimum functioning of the research equipment. If complex electronics or electrical systems are not directly repairable, the unit helps arrange experts from local or international agencies and suppliers.

Scientific Information Unit. The scientific information unit supplies the latest research and development information to agricultural scientists, planners, policy makers, and farmers. The unit maintains the central library at NARC including the latest books, journals, as well as microfilms/microfiches and video materials. The scientific information unit provides current content services at the national level and annotated bibliographies on various commodities and disciplines. NARC is the national liaison center for AGRIS, the FAO-sponsored international agricultural database. The unit provides reprographic, photographic, and audio and projection services to the various PARC/NARC units. It also publishes research results generated by the national agricultural research system.

Publications Unit. The publications unit publishes research results in the form of journals, reports, monographs, books, bulletins, newsletters, etc. and disseminates these materials to appropriate groups. At present the following periodicals and publications are issued by the NARC/PARC publication unit:

Pakistan Journal of Agricultural Research (Quarterly)
Pakistan Journal of Agricultural Social Sciences (bi-annual)
Progressive Farming (bi-monthly)
Annual Report (annually)
PARC News (monthly)
PARC Activity Bulletin (weekly)

In addition monographs, proceedings of seminars/workshops, technical and production bulletins, introductory brochures, text books, etc., are published.

Training Institute. The training institute at the NARC was established to strengthen personnel competence especially in areas which severely constrain agricultural productivity. The main aims of the institute are:

- To provide opportunities for acquiring knowledge and skills in improved agricultural production technology, management, and communication.
- To develop expertise in problem identification and in developing strategies to solve problems of food and fibre production, marketing, and processing.
- To strengthen the linkages between farmers, extensionists, and research workers by providing an environment conducive for dialogue in planning and implementing projects which aim to accelerate the transfer of technology and increase productivity.

This institute plays a leading role in training and development of agricultural scientists. The training institute, headed by a full time director, is now at the stage to plan, design and organize training in response to national needs as well as other countries. The training institute includes lecture rooms, training laboratories, seminar rooms and teaching aids, together with a cafeteria and a hostel to feed and accommodate 50 trainees. From 1983 to mid-1988, 111 workshops, and seminars, and short courses have been organized and over 3000 individuals, including federal and provincial employees and farmers have participated.

Farm Operations and Services. The farm operation and services (FOS) unit works under the direction of a farm advisory committee composed of scientists from various research programmes at NARC. This is headed by a farm manager. The main objectives of this unit are:

- To help scientists in land preparation for field experiments.
- To store and supply farm inputs like seed, pesticides, fertilizers etc., to provide field implements and tools, and arrange field irrigation, guard field area from untethered grazing animals in the neighborhood villages, control birds/animal pests etc.
- To coordinate farm labor in all the research programmes.
- To supply gasoline, washing and maintenance services for the NARC transport and to maintain all farm machinery.
- Maintenance of the canal roads and farms.

FOS has 80-major equipment items for land preparation, sowing, cultivation, irrigation, and harvesting and a complete workshop for repair and maintenance of equipment and vehicles.

Computer and Statistics Section. The computer and statistics unit was created in PARC in 1984 to provide statistical support to NARC research programmes, undertake research in biometry and agricultural statistics, and establish an agricultural statistical data bank. In addition to support services, this unit has several other objectives:

- To undertake an ad hoc agricultural surveys and statistical inquiries.
- To conduct research on developing efficient experimental designs.
- To develop short-term training programmes in biometry and computer applications for the scientists.
- To develop/test, procure, and operationalize various computer programmes and software packages for the analysis of research data.

The computer and statistical section being a service-oriented unit spends about half time on advisory consultancy and statistical computing. These services are extended to almost all research programmes of NARC. The section has a four person technical staff: one person has M.Sc in computer science and the rest have M.Sc.'s in statistics. The unit has two Apple-IIe's and 2 Wang PC's

Public Works. The works, repair, and maintenance section is headed by a project director who is assisted by a qualified graduate engineer. This section has the following assignments:

- Supervision and quality control of development projects.
- Liaison between the donor agency, consultants, and PARC.
- Site measurements, verification of bills and claims of the contractors.
- Preparation of design, estimate, and specification for small works.
- Monitoring of on-going works at NARC.

This unit also looks after day-to-day repair and maintenance of the institute buildings.

2
Research Plan, Year 2000: Purpose and Scope

Need for a Master Plan

The NARC master plan demonstrates what NARC stands for, what it hopes to achieve, and the style of research it intends to use. The aim of the research master plan is to provide a blueprint for efficiently converting NARC resources into useful products such as research results, technological information, materials, and scientific expertise.

The prime users of the research master plan would be the director general of NARC, directors, project leaders, and NARC scientists. The research master plan would provide useful information to provincial institutions and potential donor agencies.

At present, several billion dollars per year are being spent on agricultural research in developing countries. To a certain extent, the increased questioning of research goals and funding requirements is a result of past successes. As food supplies improve, the public tends to ask if additional research is essential. Fortunately the environment for research support remains highly favorable, but it is incumbent upon national research systems to establish plans that clearly state objectives and set priorities.

The international donor community also has strong interest in the planning process. Often donor assistance will be substantially increased if it is evident how a research proposal fits long-range goals. Furthermore an overall research plan helps demonstrate to the public that expenditures are well focused on national needs. The public's expectation is that research will be increasingly focused, and research entities are themselves calling for greater clarity in planning. Research directors of institutions that have grown rapidly feel the need to describe linkages between different units and to benefit from charting a course towards specific objectives. Not only does their standing as members of a research team improve, but their professional output is also more likely to be recognized.

NARC's Concept of Research

Research conducted by NARC is designed to be able to meet the urgent needs of the country quickly and efficiently, making optimal use of available manpower, physical facilities, and financial resources. The research plan will suggest reallocation of resources to solve the most important and urgent problems first, within the NARC mandate.

A conceptual model of the NARC research master plan is given in Figure 3. With this design, all levels of the organization—individual scientists, central laboratories, institutes, or research sectors—can use the plan embracing various phases of research ranging from biotechnology to studies on bread, meat, farm machinery, or farming systems.

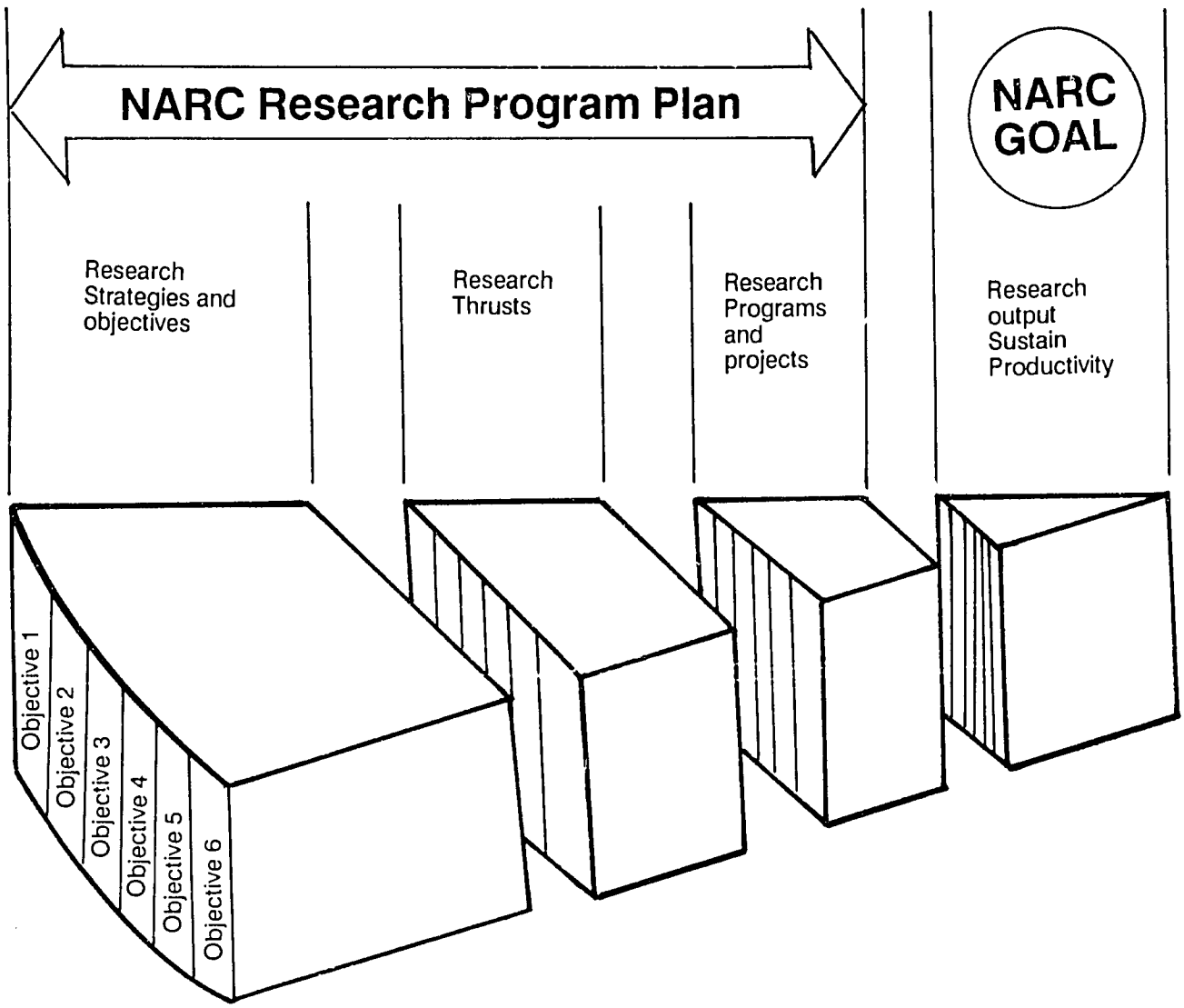


FIG 3. RELATIONSHIP BETWEEN NARC RESEARCH STRATEGIES OBJECTIVES AND APPROACHES WITH RESEARCH PROGRAMME PROJECTS AND OUTPUT

Plans are not static. NARC must respond to urgent national and international needs and to changes in government policy. Meanwhile the challenge and opportunity is to catalyze scientists to develop innovative and realistic research activities and generate the much needed improved technology consistent with the NARC research plan strategies, objectives, thrusts, and approaches.

Methodology

Both the substance of the master plan and the process by which it is developed are important. The seven steps in the plan development were as follows:

1. Plan inauguration. The chairman of PARC provided an overview of the importance and scope of the research master plan. Hard decisions relative to research thrusts and resource allocation were to be made based on the plan.

2. Questionnaire. A carefully prepared questionnaire was circulated to over 220 scientists on July 23, 1987. Scientists from 37 different projects/programmes responded to the questionnaire. Responses to the questionnaire were stratified according to scientists and disciplines. Scientists identified gaps and suggested priority research topics. Present research projects, especially those which supported provincial institutes were articulated.

3. Informal project/sector reviews. Informal meetings for review by project leaders and section heads to consider scientists responses to the questionnaire were conducted. Ideas of section unit heads for future NARC research master plan priorities to the year 2000 were articulated.

4. Formal presentations. Some 37 project/programme leaders presented their research plans to the year 2000 according to agreed format. Brief background information and purposes/goals of the unit, present research emphasis and project titles were given. A 12-year research programme focus complete with future project objectives and suggested titles was discussed by directors. Different aspects of research management (major constraints, recommended strategies, resource needs) were noted. Peer reviews after each formal presentation were conducted by outstanding scientists invited from other institutes and universities. Short term consultants reviewed each formal presentation and discussed the plans with the project leaders.

5. Master plan symposium. Technical members of PARC nominated outstanding provincial scientists to participate in a 3-day NARC research master plan symposium. The purpose of the symposium was to review the proposed research agenda and define the nature and scope of NARC's research programme to the year 2000. Strengthening the federal and provincial linkages in the agricultural research system was also emphasized. Short-term consultants who participated in the symposium prepared a report based on two short-term assignments in Pakistan.

6. Master plan draft. The director general of NARC appointed the writing team and with assistance of a consultant editor prepared the research master plan draft according to a PARC-approved table of contents.

7. Senior review panel. A PARC panel was appointed to review the NARC research master plan draft.

Establishment of Research Priorities

The setting of priorities among the research programmes and activities carried out at NARC is done in the context of various assumptions. Some assumptions relate to the mandate of NARC, some to important criteria such as potential impact of research, cost, feasibility, availability of professional staff, and level of work in progress at other institutions in Pakistan and abroad.

Commodity programmes. Table 10 presents an application of the checklist system of priority assessment for the major commodities under study at NARC at present. Simple ratings of low, medium, or high are applied to some items on the checklist, while others are dealt with on a plus or minus basis.

Table 10. **A checklist of priorities among NARC commodity programmes.**

Commodity	Climate, ecology at NARC	Fit to NARC mandate		Potential impact from NARC		Cost	Commodity importance		Staff available	Work at other centres			Indicated NARC programme (Distinct from National Coordinated Programmes)
										Pakistan		Abroad	
		Field	Adv	Field	Adv		Pres.	Fut		Field	Adv	Adv.tec	
Wheat	M	L	(+)	L	(+)	M	H	H	L	H	(-)	H	Plt Gen Res-Adv Tech
Rice	L	L	(+)	L	(+)	M	H	H	L	H	(-)	H	Plt Gen Res-Adv Tech
Maize	M	M	(+)	M	(+)	M	M	M	L	H	(-)	H	Plt Gen Res-Adv Tech
Sorghum & Millet	H	H	(+)	H	(+)	M	L	H	M	L	(-)	H	Full field; PGR Adv Tech
Fodder	H	H	(+)	H	(+)	M	M	H	M	L	(-)	M	Full field; PGR Adv Tech
Pulses	H	H	(+)	H	(+)	M	M	H	M	L	(-)	H	Full field; PGR Adv Tech
Oilseeds	H	H	(+)	H	(+)	M	M	H	M	L	(-)	H	Full field; PGR Adv Tech
Vegetables	M to H	H	(+)	H	(+)	M	M	H	L	L	(-)	M	Full field; PGR Adv Tech
Fruits	L	L	(+)	L	(+)	H	M	H	L	L	(-)	M	Plt Gen Res-Adv Tech
Sugar	L	L	(+)	L	(+)	H	H	H	L	M	(-)	M	Plt Gen Res-Adv Tech
Potato	M	M	(+)	M	(+)	M	M	H	L	M	(-)	H	Full field; PGR Adv Tech
Beef Nutn & Hlth	H	H	(+)	M	(+)	H	H	H	M	L	(-)	M	Action programs on
Dairy Nutn & Hlth	M	H	(+)	M	(+)	H	H	H	M	L	(-)	M	nutn and health
Sheep Nutn	H	H	(+)	M	(+)	M	H	H	H	L	(-)		maintenance
Poultry Nutn & Hlth	H	H	(+)	M	(+)	M	M	M	M	L	(-)	M	Adv tech (diseases)
Honeybee	H	H	(+)	H	(+)	L	L	L	H	L	(-)	M	Technology transfer
Silkworm	M	H	(+)	(?)	(+)	M	L	L	M	L	(-)	M	Low priority
Fisheries	M	M	(+)	M	(+)	H	L	M	L	L	(-)	M	Production research
Beef (Breeding)	H	H	(+)	L	(-)	H	H	H	M	L	(-)	L	Herd maintenance
Dairy (Breeding)	M	H	(+)	L	(-)	H	H	H	M	L	(-)	L	Herd maintenance
Sheep (Breeding)	H	H	(+)	M	(-)	M	H	H	M	L	(-)	L	Breeding for fine wool
Poultry (Breeding)	H	H	(+)	L	(-)	M	H	H	M	L	(-)	L	No activity

Non-commodity programmes. NARC programmes that deal with crop diseases, entomology, and weeds can be tested by the checklist technique. Those portions of the soils programme that relate to fertilizer usage are also in this category. Several other research subjects now on NARC's agenda are also distinctly within NARC's mandate and stand the test of potentially contributing to improved production of priority crops. These include tissue culture, cytogenetics, and nutrition, as well as plant introduction and germplasm preservation. Farming systems research at NARC has been mandated as one of its key areas of responsibility. It is of high priority by definition.

Definitions

Plan: A scheme and arrangements drawn up beforehand to accomplish a purpose.

Strategy: The art of conducting a systematic campaign or study.

An *objective* is a brief statement of a purpose toward which the research is directed.

A *programme is broad but carefully defined plan of a researcher (or trainer) that is usually multidisciplinary, involving the coordination and skills of scientists from more than one institution.*

A *project* is component of a programme, more specific in scope and objectives, yet more detailed in terms of what, how, where, when, and by whom the work will be done.

A *sub-project* or *experiment* is a part of a project which is carried out in the laboratory or field with even more specific objectives and work plan.

Experiment: A test made to examine the validity of a hypothesis or to determine the efficacy of something previously untried.

Research: A scientific investigation or inquiry.

Hypothesis: Supposition made as a basis for reasoning or experimentation. As a starting point for further investigations.

Strategies

Strategy 1: NARC will primarily conduct problem- or mission-oriented research in areas where provincial research is non-existent or is seriously inadequate to resolve problems of national significance.

Strategy 2: NARC will also undertake basic, long-range, high-risk research, the only source of knowledge on the basis of which new advances can be made or new contingencies met as they arise.

Strategy 3: NARC will focus on generating site-specific improved technology for various barani areas and develop means to facilitate its adoption by farmers.

Strategy 4: NARC will emphasize integrative systems research with a farming systems thrust and increased operational efficiency.

Strategy 5: NARC will provide research support services to provincial research institutes that will strengthen their capability to address local problems of agricultural production.

Objectives, Thrusts, and Approaches

The following list shows NARC's objectives, research thrusts under each objective, and research approaches. Objectives VI through IX apply to research support services.

OBJECTIVE I. Increase productivity and quality of priority crops—oilseeds, cereals, forages, pulses, and vegetables—to improve farm income, with emphasis on small farmers.

Research thrust 1: Develop basic plant growth knowledge and improved management practices, especially to maximize efficiency from fertilizers and agro-chemicals.

- Develop knowledge of basic plant growth and develop management practices for crops of economic importance.
- Establish soil test and plant-tissue test fertilizer-response correlations for major crops on benchmark soils.
- Develop seed quality, testing, and seed storage methodology for crop improvement.

Research thrust 2: Generate knowledge on basic biology of weeds, insects, and pathogens to reduce pest losses and develop low-cost integrated pest-control practices.

- Generate integrated weed and pest control technology,which includes low-cost agricultural chemical technology and management practices.
- Develop knowledge on the basic biology of weeds and insects and technology to reduce pest losses.
- Develop knowledge of etiology, epidemiology, and pathogenecity of plant pathogens and insects, and identify principles of pest control for field and horticultural crops.

Research thrust 3: Select improved germplasm of priority crops and symbiotic organisms.

- Broaden the germplasm resources of plants and beneficial organisms to ensure maximum genetic diversity in order to select for improved productivity under local environmental and soil conditions.
- Collect, classify, evaluate, and preserve germplasm and beneficial organisms and distribute them as required throughout the research system.
- Select and modify germplasm and beneficial organisms where present gaps in the research systems are identified.

OBJECTIVE II. Introduce, adapt and generate improved technology for barani areas on an integrated land use basis.

Research thrust 4: Develop improved techniques to assess and predict water available to the plant and to utilize soil moisture through improved agronomic and mechanized technology.

- Improve reliability and practicality of measuring water available to the plant from seasonal precipitation and soil-profile moisture data.
- Develop farm operations through improved mechanization and the testing of farm machinery.
- Develop cropping systems models and establish planting and harvesting dates based on calculated percentage of dependable moisture.

Research thrust 5: Generate and package improved cost-effective Barani systems for ready farmer adoption and which can sustain a sound long-term land utilization programme including agro-forestry.

- Develop improved soil and water management systems and practices to maximize water-use efficiency.
- Develop farming systems and models that integrate the use of soil, water, crops, and livestock resources for optimal management of selected land resources.
- Generate improved, cost-effective Barani systems.

OBJECTIVE III. Improve processing and minimize losses of agricultural products for human consumption.

Research thrust 6: Develop means to minimize post-harvest losses and improve processing of major food products and livestock feed.

- Develop technology to reduce post-harvest losses caused by pests, spoilage and physical and environmental damage.
- Develop means of increasing efficiency of systems for storing, processing, and distributing agricultural products.
- Characterize and quantify post-harvest losses and develop cost-effective improved post-harvest practices.

Research thrust 7: Study biological and biochemical mechanisms in plants and livestock and manipulate them to improve their usefulness.

- Develop reliable, efficient, and inexpensive methods for defining the nutritional status of agricultural commodities and processed foods.
- Devise means for improving and integrating procedures and facilities for production and transport of agricultural goods to increase productivity, reduce costs, and minimize stresses.
- Characterize the basic physical, chemical, and domestic properties of plant and livestock material that enhance their usefulness and market desirability.

- Identify and develop the means for removing intrinsic and extrinsic toxic factors in agricultural products.

OBJECTIVE IV. Establish an economically sound technology to improve livestock productivity.

Research thrust 8: Improve livestock nutrition and feed efficiency to increase productivity and quality production.

- Effectively utilize fodder and forages, non-conventional sources of protein and recycling of organic waste to increase productivity and production quality.
- Devise nutritional and physiological means for economic utilization of crop residues and the rate of synthesis of livestock products.
- Develop facilities and equipment for feedstuff preparation, storage, and improved labour efficiency.

Research thrust 9: Develop appropriate selection/mating systems and characterize useful genetic/biochemical traits to assist farmer (husbandry) practice.

- Determine and select useful genetic variations in biochemical traits in livestock to produce more productive livestock under a systematic breeding programme.
- Improve the efficiency of the reproduction process.

Research thrust 10: Establish measures, where research gaps exist, to minimize livestock diseases, parasites, and toxicants.

- Develop preventive and control measures to minimize losses from livestock diseases, parasites, and toxicants etc.
- Devise improved manure management as well as integrated housing and management practices to maximize livestock productivity.

OBJECTIVE V. Develop improved farming systems technology which optimizes resource management and packages for ready transfer.

Research thrust 11: Develop technology and methodology to collect socio-economic and management data and provide for its analysis and interpretation to guide farming systems research.

- Develop farming systems which integrate the soil-plant-livestock and management complex into a biologically sound and economically viable enterprise to make agriculture a worthwhile pursuit.
- Assess and quantify critical interactions among the different factors needed to produce and market agricultural products.

Research thrust 12: Develop improved farming systems which are biologically and socio-economically viable, including mechanization and the marketing of farm products.

- Establish and operate multivariate experiments on integrated agricultural systems to validate models and facilities for agricultural productivity forecasts.
- Develop alternative agricultural systems that substitute knowledge for resources or are less dependent upon non-renewable resources while being productive, efficient, and sustainable.

OBJECTIVE VI. Strengthen the national agricultural research system in conducting basic and applied research.

Thrust 13: Provide special laboratory analytical service including amino acids, X-ray diffraction, and atomic absorption analysis.

Thrust 14: Develop a germplasm bank to serve scientists with a ready source of diverse genetic material.

Thrust 15: Provide an effective repair and maintenance service for sophisticated laboratory equipment.

OBJECTIVE VII. Facilitate the flow and documentation of scientific and technical information.

Thrust 16: Provide library service including reference reprints and publications.

Thrust 17: Establish computerized data processing facilities and service.

OBJECTIVE VIII. Develop quality training facilities and capability for national and international seminars, workshops, and training courses.

Thrust 18: Develop training courses on technical subjects for research, extension, and farmer audiences.

Thrust 19: Conduct national and international conferences and seminars of scientific or social importance to agriculture.

Thrust 20: Strengthen research and management capability through graduate, post-graduate, and sabbatic exchange schemes.

OBJECTIVE IX. Accelerate the transfer of improved technology, methodology and information to increase agricultural production and net farm income.

Thrust 21: Strengthen linkages and packages of improved technology for ready transfer to farmers.

Thrust 22: Provide effective extension messages and methodology for farmer adoption.

Thrust 23: Develop strategies for sound policy, increased production, and optimized use of scarce resources.

3
Research Programmes, Project Linkages, Salaries, Operational Budgets

CROP PRODUCTION

Wheat, Barley, Triticale

Wheat production in Pakistan has clearly moved into a post-green revolution phase. Over the past 20 years, improved varieties have come to occupy more than 90% of the total wheat area and nearly all farmers apply fertilizer. Extensive irrigation development from canal-based systems and tubewells has led to intensification in cropping. Most irrigated wheat areas and some rainfed areas are currently double cropped.

Most of the potential for gains has already been achieved and it is unlikely that there will be substantial net increases in the total wheat area. Expansion and intensification in land use has led to compromises in the management of the wheat crop, such as late planting in order to accommodate other crops in the rotation.

The land use trends in Pakistan suggest that future growth in wheat production will come primarily from raising yields on existing wheat lands, and in all likelihood, under greater agro-ecological stresses. An apparent tapering off in the growth of wheat yields has raised the question as to whether production will keep pace with demand. Although 10% of the nation's wheat-producing areas still grow tall, traditional varieties, it is clear that yield gains from high yielding variety introductions and increases in fertilizer use per hectare will not be major factors impacting production in the future.

Wheat management research aimed at resolving area-specific production problems will narrow the yield gap. National average yields are still below 2 t/ha, but good farmers and experimental stations obtain yields of over 7 t/ha.

Specifically the major problems of wheat production are:

- Continual need for high yielding disease- and stress-tolerant varieties adapted to major agro-ecological zones.
- Poor land preparation, planting methods and other agronomic practices which result in poor stand establishment.
- Improper fertilizer and irrigation practices that result in low crop response to applied nutrients.
- Poor tilth and conservation practices which affect soil moisture use efficiency of crops.
- Excessive weed and pest damage.
- Mechanical and pest damage during harvest and post-harvest operations and storage.

- **Lack of improved technology packages that will resolve whole farm constraints for wheat-based systems.**

Goals and objectives. The principal aims of the wheat, barley and triticale programme are:

- To develop improved, high yielding, disease- and stress-resistant varieties with dependable yields and good quality grain.
- To generate new technology for efficient use of inputs to improve productivity in wheat-based cropping systems.
- To increase wheat productivity in marginal areas, especially rainfed and special problem areas.
- To raise the yield potential of wheat varieties through innovative technologies.
- To emphasize on-farm wheat research with a farming systems perspective oriented towards solving farmers' problems.
- To develop methodologies to generate new understanding and thereby find solutions to specific wheat research problems.

Mandate. The NARC wheat, barley, and triticale programme mandate is to optimise, through interdisciplinary research and related activities, the production, quality, and dependability of these crops in various agro-ecological zones of the country, especially in barani lands. The wheat programme seeks to fulfill this goal by the development of stable, high yielding germplasm and the development of appropriate crop management practices through on-farm research. To accomplish its purpose, the programme will focus increasingly on strategic research aimed at understanding resistance to biotic stresses and tolerance of biotic stresses.

Current programme. The wheat programme is involved in a number of research activities in addition to serving as an important cooperating unit of the coordinated programme. Germplasm improvement for obtaining stable yields in marginal rainfed environments is a primary objective. Identification of genetic variability for drought and disease resistance and its incorporation into desirable backgrounds is an important activity. Other germplasm-related activities are germplasm introduction from international sources and its evaluation and distribution.

With greater emphasis now being placed on improving farm productivity, taking into account the total farming system and the need to orient agricultural research towards the needs of small farmers, a farming systems approach is being implemented by the wheat programme through strong on-farm and experiment-station research aimed at the major cropping systems of the country. Using this approach, scientists look at wheat as an integral part of a cropping system and analyze technological issues in wheat production in relation to the total productivity of the cropping system.

Work has been initiated on testing the accuracy of a computer simulation model (CERES) and its modification if needed. Crop modelling has increasing potential to make crop management research more efficient and thus could serve as a strategic agronomic research activity.

The wheat, barley, and triticale programme, NARC, will serve as a key and important focus of national coordinated programme activities. These would relate especially to (1) participation in on-farm research activities in barani areas (2) development, introduction, collection, and evaluation of germplasm and subsequent distribution to provincial programmes. The NARC wheat programme will continue to play a key role in the conduct of the national uniform testing programme.

Proposed programme

Priority 1

- Development, introduction, evaluation, and distribution of germplasm.
- Multilocation testing (NUWYT) and evaluation.

- Development of high yielding, disease- and stress-resistant varieties for rainfed situations and problem soils.
- Development of improved cultural practices for the barani wheat-based cropping patterns through on-farm work.
- Development and use of computer simulation models as a tool for crop management research.
- Diversification of the genetic base of rust resistance in commercial wheats.
- Individual cell-level screening for disease resistance.

Priority 2

- Study, development, and use of efficient breeding methodologies.
- Use of haploid doubling for accelerating variety development.
- Study of wheat multilines and mixtures.
- Interspecific and intervarietal hybridization for obtaining a quantum jump in yield.

Priority 3

- Development of wheat hybrid technology and heterotic pattern identification.
- Development of techniques for studying multiple wheat-based cropping systems.
- Development of wheat (durum) that suits export requirements.

Advanced research. A number of activities of strategic and basic nature will be initiated or strengthened at NARC. These include wide crosses to transfer desirable genes from other species, use of recombinant DNA techniques for transfer of desirable characteristics, and tissue culture technology for effective and quick evaluation of germplasm response to stresses, thereby speeding the variety development process.

Linkages and relationships. On campus, the wheat, barley, and triticale programme has close coordination and joint approach for addressing research issues. Germplasm collection, introduction, evaluation, and development: PGR, quality, CDRI, tissue culture; national uniform testing programme: CDRI, quality, statistics and computer; computer simulation modelling project: agro-meteorology, water resources, soils; long-term barani wheat-based cropping system project: water resources, soils, weed science, pulses, fodder, maize, pathology, microbiology, AERU; on-farm research in ICT: transfer of technology, AERU, crop maximization programme, weed science, soils; on-farm research in Fatehjang: farming systems research, water resources, soils, weed science, pulses, fodder, maize, pathology, microbiology, AERU, livestock; rice/wheat: oilseeds, weed science, rice, PMP, food legume, FMI, CMP, AERU, FSR.

The wheat programme by playing a key role in the coordinated programme is closely linked with a number of research centres in provinces. The activities of germplasm introduction, its evaluation, and distribution in addition to joint work in on-farm research in a number of target areas serves to strengthen these linkages. The national uniform testing programme is another joint activity of special significance.

In the past, such international centres as CIMMYT and ICARDA have contributed significantly to wheat improvement efforts in Pakistan by providing germplasm and also by training Pakistani wheat scientists. In future this association would continue to be useful with following emphases:

- Organizing training courses for wheat scientists within Pakistan with the help of international centres.
- Training of master trainers, who could then train a larger number of scientists in Pakistan.
- Help in developing a methodology of farming systems research focusing on wheat.

- More input into the economics research programme in Pakistan.
- Continued availability of germplasm.

The wheat programme is in touch with the farmers of ICT through the transfer of technology programme and with the farmers throughout the country through the mass dissemination of the annual Urdu publication containing wheat technology recommendations. The annual wheat travelling seminars provide feedback to scientists about issues related to wheat research. In addition, the wheat programme is involved in training courses and seminars, on-farm research, and demonstration work in a number of agro-ecological zones, and farming systems research activities in various target areas.

Expected accomplishments. Objectives achieved will include greater efficiency and stability of production, increased profitability, improved nutritional values, more resource saving technologies, and a more competitive position for trade on international markets. Specifically:

- A wide range of desirable germplasm from international sources and NARC will be made available to wheat scientists in the country.
- Through conventional methodologies and biotechnological approaches, high yielding germplasm will be available leading to quicker variety development and release.
- Through the national uniform testing programme, a range of improved wheats, barleys, and triticales will be released as commercial varieties.
- Wheat production technologies for the wheat-based cropping systems will be fine-tuned and available to the farmers for substantially increasing yield.
- Germplasm with stable disease resistance capable of withstanding epidemics will be available.
- Computer simulation models which will forecast production, warn of disease epidemics, suggest management interventions, and predict genotype performance in various agroecological zones will be in use.
- Sustainable yields of barani wheats will be possible through an improved package of technology consisting of new high yielding varieties and recommended management practices.
- Durum wheats which meet the quality standards of export markets will be available.
- Effective collaboration with national and international wheat improvement programmes will be achieved.

Rice

Although experimental rice yields have increased dramatically, farmers' yields remain low. Further, with the advent of new technology, rice yields have increased consistently in the region, but Pakistan's yields have been stagnant since the mid 1970's. This situation calls for studies to learn more about farmers' problems and to develop appropriate technology for easy adoption. The rice programme emphasis is to narrow the yield gap between research stations and farmers' fields, to reduce harvest fluctuations, and to conduct basic studies to raise yield potential.

The major production problems are:

- Need for high yielding, insect- and disease-resistant varieties with good cooking and eating qualities.
- Low plant population per unit area.
- Infertile soils and inferior fertilizer management.
- Reduced yields due to biological and physiochemical stresses (insect pests, diseases, weeds, salinity, temperature).
- Pre- and post-harvest losses due to lack of proper machinery.

- Socio-economic constraints such as shortage of labour, credit facilities, right type of inputs, etc.

Goals and objectives. The principal aims of the rice programme are:

- To increase knowledge about rice and the environment within which it is grown and to provide improved technology that will lead to sustained increases in the productivity and profitability of rice.
- To generate appropriate technology and information for the rice industry to improve competitiveness in international trade.
- To identify effective means for verification and transfer of technology through outreach activities.

Mandate. The rice programme is to conduct multidisciplinary research not carried out by provincial institutes to increase productivity, profitability, and sustainability of rice culture, to conduct basic research on rice plant to solve strategic problems, to evaluate and preserve genetic material in collaboration with plant genetic resources, to increase activities that complement and augment provincial programmes, and to develop short courses at NARC to train national scientists.

Current programme. The rice programme tests adaptability, yield performance, and grain quality of nurseries received from national and international sources. Crop and soil management studies deal with fertilizer usage, weed control, and direct seeding of rice. Pest management work includes studies of the population dynamics of different insects, the screening of breeding materials, and the evaluation of stem borer incidence in cropping patterns which include zero tillage of wheat. Grain quality studies relate to milling efficiency, cooking qualities, and other characteristics of basmati rice.

Proposed programme

Priority 1

- Basmati varietal improvement through innovative means, develop direct seeding technology, and screening germplasm for resistance to biotic and abiotic stresses.
- Genetic and inheritance studies for pest resistance and quality parameters of rice varieties through incorporation of desirable genes (coordinated programme).
- Effect of different rice-based cropping systems and cultural practices on carry-over of insect pests, their natural enemies and rice agro-ecological systems (coordinated programme).

Priority 2

- Physico-chemical characterization and fertility management of rice soils for high productivity and fertilizer use efficiency.
- Effect of environmental plant stresses on the level of resistance against insect pests and their relationship with host plant which can be used as selection markers in breeding resistant varieties.
- Studies on storage conditions, environmental factors, and cultural practices that influence rice grain quality. Assessment of post-harvest losses and development of rapid and simple techniques to evaluate rice grain quality.

Priority 3

- Assessment of socio-economic implications of new technology and identification of practical means for its adoption.

Linkages and relationships. At NARC campus, the rice project will collaborate with tissue culture laboratory, soil laboratories, farm machinery institute, social scientists, CDRI. In national

coordinated programmes, the NARC unit will conduct agreed upon studies with international centres such as IRRI and advanced laboratories of developed countries. To demonstrate improved technology in farmers' fields on large scale, the programme will run rice yield optimisation programmes with the involvement of local extension staff.

Expected accomplishments. The yield and quality of rice will be raised through conventional and innovative varietal improvement, incorporation of pest-resistance genes, better understanding of agro-ecosystems, exploitation of parasites and predators, soil fertility management, and improved cropping systems. These studies will also establish integrated pest management on sound basis which will reduce the losses incurred by insect pests and diseases. The production of rice may increase up to 50 percent. Moreover, yields of wheat, chickpea, pulses, fodder crops etc. in rice-based cropping systems will increase considerably (30 to 40%).

Maize

To close the gap between actual and potential production levels, maize varieties need to be developed for low rainfall conditions. Varieties also need improved resistance to diseases and insects. The development of high yielding, early maturing maize varieties and better technology will enable farmers to increase their production and make maize a more profitable crop.

The major constraints of maize production are:

- Continual need for high yielding, early maturing, disease- and stress-tolerant varieties and hybrids especially for barani conditions.
- Excessive weed and pest damage.
- Dual purpose use of maize for fodder and grain reduces grain yields.
- Poor fertilizer and irrigation management.

Goals and objectives. The principal aims of the maize programme are:

- Development, improvement, and consolidation of high yielding, early maturing maize germplasm resistant to drought, diseases, and plant density stresses.
- Development of packages of technology acceptable to, and economical for, resource-poor farmers in drought-prone, high risk areas.
- Identification of effective ways to verify and transfer new technology.

Mandate. The NARC maize sector mandate is to conduct interdisciplinary research to increase both yield and quality of maize in Pakistan. Research thrusts include development of basic plant growth knowledge, improved cultural practices, and selection of improved germplasm. Special focus will be on improved barani maize technology in a systems context.

Current programme. The coordinator of the national coordinated programme for maize is based at NARC. As part of its mandate, the NARC group screens and evaluates germplasm from international sources. Maize breeding work carried out at NARC relates particularly to the needs in the region of Islamabad in which the NARC station is located and in similar areas elsewhere in the nation. Maize for fodder as well as for grain is important. Early and medium maturing lines are needed particularly drought-tolerant types. Weed control work in barani maize is currently under way. Agronomic studies include work on fertilizer usage. Studies in maize pathology include work on stalk rot. The field biology of stalk borers is under study. Other work on these pests includes screening for resistance and evaluation of insecticides for their control.

Proposed programme

Priority 1

- Development and evaluation of maize germplasm for tolerance to drought and cold using genetic, chemical, and physiological diversity in field and laboratory investigations.

- Application of heterochromatic knob composition in predicting combining ability and tolerance for inbreeding depression in maize.
- Modelling, verifications and demonstration of input levels for economical cultivation of maize under barani conditions through farming systems research.

Priority 2

- Biological parameters related to host plant resistance in maize varieties against *Chilo partellus* (stalk borer).
- Evaluation of row vs broadcast planting in maize intercropped with legume fodders at different densities and fertilizer levels under barani conditions.
- Interrelationships of grain moisture, seed quality and storage conditions in the development of aflatoxin.

Priority 3

- Evaluation of maize populations containing different proportions of exotic and adapted germplasm.

Priority 4

- Development and evaluation of maize germplasm for tolerance to salinity using biotechnology.

Linkages and relationships. On campus, the maize project will require participation from agronomy, animal nutrition, soil, food laboratories, CDRI, farm mechanization, agricultural economics, FSR, and statistics. The maize unit at NARC will be an active member of the national coordinated programme involving provincial centres and will conduct agreed upon tests regarding maize in the climatic zone of Islamabad. The unit will work with other Pakistani centres where site-specific maize research is in progress. This will be normally through farming systems research projects. Collaboration will also be arranged with centres where advanced research is in progress including biotechnology studies at universities, maize research institutes, Atomic Energy/agricultural research institutes, etc.

The maize unit at NARC, working with the plant introduction unit, will receive genetic materials from such international entities as CIMMYT, ICARDA, FAO, and USDA. Some nurseries will need to be planted for screening or evaluation at NARC as well as at other cooperators within the national coordinated programme. Others would be potential parental lines for long term preservation.

The NARC maize team will also be responsible for evaluating materials for desired characters and selecting ones for inclusion in the gene bank. They will work with the plant genetic resources unit in increasing germplasm from time to time to ensure that viable seed reserves are available.

Making use of physical facilities at NARC and drawing on scientists with special expertise, NARC should handle such studies as grain quality evaluation, stress tolerance selection criteria, marker-facilitated selection of quantitative traits, cailus culture, and individual cell level screening for disease resistance in collaboration with scientists overseas who have similar interests

As maize research generates improved technology, its transfer will take different forms depending upon the audience. FSR projects will provide an important means by which farmers may validate improved maize technology in their farming systems. Assessment will be in terms of increased productivity, net farm income, and resource allocation changes.

Expected accomplishments

- Approximately 200,000 hectares of maize planted under low rainfall conditions will benefit from germplasm developed for better performance under such ecology The average yield of about 1.0 tonne per hectare under such conditions will rise to

approximately 1.5 tonne per hectare. Hence an increase of about 100,000 tonnes in total production is expected. Similarly the area under spring maize will increase from 40,000 hectares to 100,000 hectares owing to the availability of germplasm which can do better under low temperature conditions. This increase in area and hence in production will be accomplished by shifting the planting date from Februrary-March to January.

- An approximate increase of 20 to 25% in production is envisaged from popularisation of hybrid maize cultivation as a result of modelling of economic input levels for hybrid cultivation.
- The cost of production will be lowered by about Rs 150/ha by eliminating insecticide expenditures.
- Tremendous saving in time and resources in hybrid development for breeders all over the country and elsewhere will be achieved if success in predicting combining ability of maize inbred lines through heterochromitin knobs composition studies is accomplished.
- By developing maize genotypes which can tolerate broad spectrum herbicides, weed control will be easier and cheaper.
- Post-harvest studies on the development of aflatoxin in stored grains will reduce the health danger to millions of farmers and their families.
- By modifying and developing maize genotypes which could be successfully grown in saline conditions, thousands of additional hectares may be brought under the crop.

Sorghum and Millet

Sorghum and millets are important coarse grain crops in Pakistan especially in areas where drought is common. Despite their economic significance these crops have received little attention compared with wheat and maize. The present national yields of sorghum and millet are 587 kilograms and 461 kilograms per hectare, levels which are far below the potential (2500 to 3000 kilograms per hectare). The gap can only be reduced by developing varieties with desirable characters for each ecological zone of the country, coupled with the improved package of technology acceptable to the farmers.

The major production problems are:

- Diminished yields due to infertile soils and conditions of moisture stress.
- Reduction in yields due to weed infestation.
- Improper tillage and planting practices that lead to poor stands.
- Damage from shoot fly, stem borer, armyworm, grasshoppers and diseases including red leaf spot, leaf blight and downy mildew.
- Bird and wild boar damage especially in early maturing varieties.

Goals and objectives. The principal aims of the sorghum and millet programme are:

- Evolution, development and improvement of high yielding, early maturing sorghum and millet varieties and hybrids resistant to drought, pests, and diseases and responsive to plant density and fertilizer.
- Development of production package of technology acceptable and economical for the farmers in rainfed areas.
- Identification of the ways to verify and transfer the improved technology through outreach research and farming systems research activities.

Mandate. The sorghum and millet research programme is to improve sorghum and millet production in Pakistan through selection of better varieties and development of suitable practices and to coordinate and strengthen research activities in the provinces. Specifically it is to establish

an interdisciplinary and interprovincial sorghum and millet variety development programme by means of incorporation of superior exotic and local germplasm and testing simultaneously for insect and disease resistance. The programme is also responsible for arranging discussions and evaluation of the research projects in meetings at national and provincial levels, and planning for further development.

Current programme. The NARC unit regularly receives breeding materials from abroad, mainly from ICRISAT, but also from the USA and elsewhere. These are tested at NARC and distributed to provincial stations as part of the national coordinated programmes for the commodities. The NARC sorghum and millet team also actively collects, evaluates, and conserves native germplasm of Pakistan in cooperation with the NARC genetic resources unit. An active sorghum breeding programme is under way based on pure-line selection of native materials and on crosses with exotic materials. Selection is focused on earliness, seedling vigor, and grain and forage yield and quality. Crosses with exotic lines aim for intermediate height and adaptation to various ecological zones. The final product of the breeding programme must be superior cultivars that are well adapted to local environmental conditions. Experience has shown that this is best achieved by crossing local and exotic materials. Hybrids developed at other institutions, particularly ICRISAT, are tested at NARC. Such testing involves evaluation of parental lines and local production of hybrid seed. Studies in agronomy are focused on planting dates, plant population in sorghum, and responses of sorghum to nitrogen fertilizer. Millet is investigated in a parallel programme as regards collection of local germplasm and development of national and international trials.

Proposed programme

Priority 1

- Collection, evaluation, and conservation of local sorghum germplasm in collaboration with plant genetic resources unit at NARC.
- Development of high yielding dual purpose (grain cum forage) varieties.
- Screening of local and exotic germplasm and segregating generations of crosses for tolerance to stress conditions, particularly drought, heat, salt, and emergence through crusted soil surface.
- Development of hybrids and composites of sorghum and millet.
- Testing of the national and international germplasm in observation nurseries and replicated trials.
- Development of sorghum varieties having the stay-green character and better biomass production.
- Demonstration of improved production technology through on-farm and farming systems research trials and analysis of the economics of these crops.

Priority 2

- To conduct surveys to determine which diseases and pests are causing the greatest losses to sorghum and millet crops and to breed for resistance to them.
- Studies on intercropping, weed control, sowing dates, fertilizer use and plant population for sorghum and millet varieties.
- Mechanization of sorghum and millet production with regard to tillage operations, plant stand establishment, use of drill in sowing, and use of machines for harvesting and threshing, in collaboration with farm machinery institute.

Linkages and relationships. On campus, the sorghum and millet project will require participation from agronomy, soil, fertility, plant protection, farm mechanization, agricultural economics, and farming systems research.

In work with provincial centres, the dual assignment which at present causes the national coordinator for sorghum and millet to also serve as principal sorghum and millet investigator for NARC will be separated into two positions. The sorghum and millet unit at NARC will be an active member of the national coordinated programme and will conduct agreed upon tests regarding sorghum and millet in the climatic zone of Islamabad.

The programme will collaborate with other Pakistani centres where site specific sorghum and millet research is in progress. This will be normally through the farming systems research project. The programme will also collaborate with centres where advanced research is in progress including bio-technological studies at universities, and Atomic Energy/NIAB institutes, etc.

The sorghum and millet unit at NARC working with the plant introduction unit will receive genetic materials from ICRISAT and other international centres. In plant genetic resource preservation, the NARC sorghum and millet team would be responsible for evaluating materials for desired characters and selecting those for inclusion in the gene bank. They would also work with the plant genetic resources unit in increasing germplasm from time to time to assure that viable seed reserves were available.

Expected accomplishments.

- With the evolution of new varieties with desirable characters coupled with improved production technology, average yields of sorghum and millet will be enhanced by 50%.
- Some 2000 accessions of sorghum germplasm and millet germplasm from local land races and abroad will be collected and conserved for the breeding programme in collaboration with PGR Unit at NARC.
- Ten sorghum varieties and eight millet varieties or composites having dual qualities (grain cum forage) with early maturity, and other desirable characters, like tolerance to drought stress, heat and salt, will be released.
- The package of production technology for sorghum and millet will be improved with regard to fertility, plant density, weed control, tillage operations and screening of insecticides and fungicides, and control of major insects pests and diseases.

Fodder Crops

Livestock, the most important component of barani farming systems, is totally dependent on fodder production, which in fact determines the cropping patterns in these areas. Traditionally crops like sorghum, millet, and maize in Kharif and mustard and barley in Rabi are grown for fodder production in these areas with very low yields. The cause is the small parcels of land that are cultivated, the use of out-moded local varieties with low yield potential, and poor production technology. The use of improved cultivars and the production technology pertaining to different fodder crops will bring about a tremendous increase in quality fodder production in the country, thereby enhancing the income of the farmer.

The main problems of fodder production are:

- Need for introduction and evaluation for high yielding, nutritious, and stress resistant fodder varieties.
- Lack of suitable multicut fodder crops, especially legumes, for fodder deficit periods.
- Poor quality seed.
- Farmer use of poor cultural practices.
- Lack of technical information on livestock performance under grazing or when fed green chop, hay, or ensilage.

Goals and objectives. The principal aims of the fodder crop programme are:

- To develop an integrated national fodder research programme whereby each research institution would constitute a vital component of the system with NARC at Islamabad as a nucleus institute of this programme.
- To establish a world-wide collection of germplasm of fodder varieties and species for testing, screening, evaluation, and distribution to the provincial institutes to enable them to develop varieties to cover different agro-ecological conditions.
- To evolve superior fodder varieties through selection, breeding, and improvement of fodder crops for irrigated and rainfed areas of Islamabad capital territory and Rawalpindi.
- To develop sorghum and millet cultivars for fodder cum grain purpose in close cooperation with sorghum and millet programme.
- To conduct agronomic research to maximize the yield of important fodder crops.
- To conduct studies on fitting fodder species into different farming systems and ecological zones with emphasis in barani and mountainous areas to develop an intensive fodder-livestock integrated system.
- To evaluate fodder quality through biochemical analysis, feeding, and digestion trials in close cooperation of Animal Sciences Institute, NARC.
- To develop seed production techniques and facilities for foundation seed production for the outreach programme.
- To develop an outreach programme through on-farm testing of improved varieties and production and management technology.
- To develop fodder varieties suitable for poor soils and rainfed and hilly areas.

Mandate. The fodder programme at NARC is to conduct research on the development, maintenance, and evaluation of worldwide germplasm of fodder crops and to distribute germplasm to the provincial fodder research units for its testing and variety development for different agro-ecological zones in the country.

Current programme. The fodder programme focused first on traditional fodder crops such as sorghum, millet, and maize in Kharif and on ones like mustard and barley in Rabi. Attention has turned to other crops as well, including lucerne, berseem, oats, elephant grass, and cowpea. The fodder programme has participated in collection, evaluation and maintenance of indigenous germplasm for various fodder crops and in assembling exotic germplasm. Independently or in collaboration with other NARC units the fodder research group has maintained a crossing programme to improve the quantity and quality of fodder. Particular attention has been given to sorghum and millet and sorghum-sudan grass crosses.

Proposed programme

Priority 1

- Collection, screening, evaluation, distribution, and maintenance of exotic and indigenous germplasm of fodder crops in collaboration with the plant introduction centre and plant genetic resources.
- Determination of the effect of mechanized fodder production using improved production technology on milk and meat production in collaboration with FMI and ASI.
- Determination of the exact proportion of supplementation of dry fodder by green fodder of different types and its implication on the economical production of milk and meat in collaboration with ASI.
- Breeding for development of drought , disease- and cold-tolerant fodder varieties of

high nutritive value, with emphasis on problem soils and marginal lands.

- Evaluate and promote multicut and new high yielding fodder crops varieties to develop a year-round supply of green fodder to improve animal production systems in the country.
- Determine the flexibility of fodder production in different agro-ecological zones through agronomic management practices such as sowing dates, cutting heights, and fertilizer application.

Priority 2

- Fitting of improved fodder varieties in different systems and cropping patterns through on-farm research to develop efficient fodder-livestock production systems for different agro-ecological zones.
- Quality determination for crude protein, crude fibre, etc. including minerals of economic importance and promising varieties of different fodder crops.

Priority 3

- Determine hay making and silage options for surplus fodder production and assess its effect in terms of a package on the income derived through increased production of livestock by-products.
- Conduct biological nitrogen fixation studies on fodder legumes and determine its effect on the growth and yield of cereal crops in collaboration with BNF program.

Linkages and relationships. Strong linkages between the NARC unit, provincial units, international centres of excellence and integrative systems of fodder-livestock production be developed to solve the complex problems of fodder research and production for a sound livestock development programme. The programme is actively collaborating with plant genetic resources for testing and evaluating the germplasm received from plant genetic resources and for its preservation for use in future breeding programmes. The fodder research programme collaborates with Agricultural Research Institute, Tarnab (Peshawar); Agricultural Research Institute, Sariab (Quetta); Agricultural Research Institute, Tandojam (Sind); Fodder Research Institute, Sargodhe; Livestock Production Research Institute, Okara; University of Agriculture, Faisalabad (PBG); and University of Agriculture, Faisalabad (A.N.) and livestock experiment stations and project centres where specific research on fodder crops is being undertaken.

Expected accomplishments

The following accomplishments are expected to reduce the fodder shortage by 75%:

- The development and evaluation of germplasm will help in selection of varieties with desirable characters which will be tested for barani and hilly areas of the country.
- An improved package of production technology will be developed and standardized for barani and hilly areas.
- Improved cultivars will be fitted into the different farming systems and cropping patterns. Fodder deficit periods will also be covered through varietal development.
- Promising improved varieties will be evaluated for nutritive value with the help of digestibility trials and feeding trials and through proximate analysis by integration of fodder-livestock systems.
- The quality of cereal fodder crops will be improved by growing these crops in association with fodder legumes.
- Improved production technology will be evaluated on the basis of cost-benefit ratio in different cropping patterns and cropping systems.

Pulses

A narrow genetic base in pulses, lack of high yielding, early maturing varieties, lack of appropriate production technology, disease and insect problems have resulted in pulse shortages. The development and introduction of improved production technology, high yielding varieties with disease and pest resistance will ultimately increase the pulse production in the country to meet the protein requirements of the growing population. The major problems of pulse production are:

- Pulse diseases and variability in pathotypes responsible for breakdown of the resistance of the varieties.
- Instability of good yielding, stress-resistant hybrids in the main pulse growing areas.
- Unavailability of pulse cultivars responsive to improved management on better soils. Cultivars need better partitioning between the total biomass and economic yield (grain yield).
- Poor stand establishment especially in chickpea and lentil, mainly due to improper tillage and sowing methods on poor soils.
- Poor moisture conservation technology on marginal land for pulses growing.
- Weeds and pests.
- Post-harvest losses in both the field and store.

Goals and objectives. The principal aims of the pulses programme are:

- To screen genetic material of major pulses for desirable characters.
- To use desirable genetic stock for varietal improvement with respect to high yield, yield stability, short growth duration, drought tolerance, and resistance to major diseases.
- To develop appropriate production technology for increased production and productivity with the use of rhizobium inoculum and various agronomic techniques to raise the income of small farmers of barani areas.

Mandate. The NARC pulses sector is to conduct interdisciplinary research to increase both yield and quality of major pulses (chickpea, lentil, mung, and mash) in the country.

Current programme. The pulses programme at NARC is responsible for screening and evaluation of pulse crops germplasm (especially of chickpea, lentil, mung and mash) for characters such as high yield, short duration, plant type, determinate type, and resistance to pests and disease. Breeding for disease resistance in chickpea, mung and mash is also in progress. Breeding material is supplied to the provincial units for their selection. Evaluation of national uniform yield trials; developing production technology through the use of rhizobium, appropriate plant population, fertilizer use, and weed control; and involvement in farming system research in Fatehjang areas are the present activities of this programme. Investigation of B.T. for the control of chickpea pod borer has recently started. Studies on blight races are also being conducted.

Proposed programme

Priority 1

- Evaluation of germplasm material of chickpea, lentil, mung, and mash for characters like high yield, short duration, drought tolerance, and disease resistance.
- Breeding of chickpea, lentil, mung, and mash for development of high yielding varieties with desirable characters.

Priority 2

- Studies on improved agronomic practices which can provide effective weed control, high plant densities, and positive response to high levels of inputs with special reference to rhizobium and fertilizer use in collaboration with microbiologists.

- Introduction of improved pulse production technology for raising small farmers' income in the barani areas through strong collaboration with farming systems research.

Priority 3

- Studies on the race spectrum of chickpea blight caused by *Ascochyta rabiei.*

Priority 4

- Studies on use of *Bacillus thuringenesis* (B.T.) for the control of chickpea pod borer.

Advanced research. At present two major problems are being faced in case of chickpeas, which alone contribute 85% of total pulses production. The first is blight disease caused by (*Ascochyta rabiei*) and the second is Heliothis pod borer (*Heliothis armigera*). Advanced research will involve establishing the race spectrum of *A. rabiei* and use of B.T. for Heliothis control, with coordination of crop disease research institute and entomological laboratories at NARC.

Linkages and relationships. At NARC the pulses programme will have close coordination with biological nitrogen fixation, soils laboratories, stress physiology, crop diseases research institute, entomology laboratories, farm machinery institute, nutrition laboratories and farming systems research.

With provincial centres, NARC pulses unit will develop breeding material keeping in view the national requirement for provincial research units and will also be an active part of the coordinated programme on pulses to conduct research in Islamabad Capital Territory areas. Where site-specific research on pulses is in progress at other Pakistani centres, collaboration will be through farming systems research programmes.

The pulses units at NARC working with the plant introduction unit would receive genetic materials from AVRDC, ICRISAT, and ICARDA for evaluation. Some specific international nurseries will also be tested. Others would be potential parental lines for long-term preservation. The pulses programme team would be responsible for evaluation of materials for desired characters and selecting them for inclusion in the gene bank. They would also work with plant genetic resources unit in increasing germplasm from time to time and for characterization.

Expected accomplishments

- Germplasm material of chickpea, lentil, mung, and mash shall be characterized for high yield, short duration, drought tolerance, and disease resistance.
- Through hybridization of pulse crops, high yielding varieties with desirable characters shall be developed.
- Effective pulses production technology shall be developed.
- Improved production technology will be introduced in the barani areas through farming systems research to boost the small farmers' income.
- Different races of chickpea blight caused by *Ascochyta rabiei* shall be studied and identified.
- Possibility of biological control of chickpea pod borer by use of *Bacillus thuringenesis* will be explored.
- Pigeonpea, cowpea, and common bean germplasm shall be characterized and catalogued for introduction as new pulse crops.

Oilseeds

To help cope with Pakistan's deficit in edible oil production, efforts are being made to introduce new oilseed crops such as sunflower, soybean, and safflower in addition to raising production of conventional oilseeds. There is a general consensus among scientist and planners that sunflower has the potential to become the main oilseed crop in the country.

Little research work has been done on oilseed crops. Research topics such as breeding, agronomy, pathology, entomology, physiology, by-product utilization, economics, farming systems, oil and meal quality, farm machinery development, and seed storage remain unexplored and need immediate attention. The major problems of oilseed production are:

- Need for continual selection and development of high yielding, early maturity, disease-resistant oilseed varieties adapted to rice- and cotton-based systems and barani areas.
- Lack of promiscuous cultivars of soybean.
- Lack of field equipment to facilitate planting, harvesting and threshing.
- Lack of proper cold storage facilities to maintain seed viability.
- Lack of improved production packages that will resolve whole farm constraints for soybean-based systems.

Goals and objectives. The principal aims of the oilseeds research program are:

- To collect, evaluate, and distribute germplasm.
- To develop and improve local hybrids and varieties for high yield, short stature, early maturity, drought resistance, and high oil and meal quality.
- To develop selected oilseed production technology to increase production in Pothwar plateau.
- To breed for resistance to diseases and insect pests of each crop.
- To evaluate the economic return from fitting oilseed crops into different crop rotations under various farming systems.
- To develop of farm machinery for planting, harvesting and threshing of each crop through FMI.
- To improve the efficiency of by-product utilisation.

Mandate. The mandate of the oilseeds research program of NARC is to strengthen research activities on sunflower, soybean, safflower, rapeseed-mustard, and groundnut. The focus will be the development of varieties and hybrids that have high yielding ability and that are high-temperature and drought-tolerant, early maturing, short in stature, and resistant to diseases and insect pests. Development of appropriate production technology will also be regular activities of the programme. Since non-conventional oilseeds are new crops in the country, all newly evolved material will be tested in different farming systems.

Current programme. Major efforts are directed to the evaluation of germplasm for selecting genotypes which are well adapted under the local environment. Development continues in the maintenance of restorer and CMS lines for producing sunflower hybrids together with the development of '00' varieties of rapeseed-mustard and short duration and high yielding varieties of groundnut and soybean. Studies on optimum plant population per hectare; sowing time, harvesting time, and application of herbicides and nutrients are carried out to improve production technology. Under the programme of breeding for disease resistance, diverse material is screened in order to select for charcoal-rot resistance. To test sunflower in establishing systems, cooperation is extended to the intensive farming system research programme in the Fatehjang area.

Proposed programme

Priority 1

- Evaluation and screening of germplasm of groundnut, rapeseed-mustard, sunflower, soybean, and safflower to select genetic sources for improvement of base populations and varieties.

- Development of local inbred lines of sunflower having desirable traits such as early maturity, short stature, semi-erect heads, high oil content, and drought and disease resistance.
- Improvement of the existing varieties of rapeseed-mustard and development of new ones having '00' character for erucic acid and glucosinolates.
- Development of short duration, high yielding groundnut with resistance to common pests and diseases.
- Generation of segregating material for the development of soybean varieties with early maturity and high yield.
- Breeding for resistance in sunflower to charcoal-rot.
- Determining the economic threshold of major insect pests and evaluation of control measures including pesticides, biological control, and microbial agents with the collaboration of the entomology research laboratory.
- Develop machinery for planting, threshing and harvesting for oilseed crops in collaboration with FMI.

Priority 2

- Breeding for collar rot resistance in sunflower.
- Breeding for aphid resistance in rapeseed-mustard.
- Breeding soybean varieties resistant to yellow mosaic virus, pod blight, and purple seed stain.
- Develop production technologies for sunflower, soybean, rapeseed-mustard, and groundnut for barani areas around ICT.
- Study economic returns by fitting sunflower and soybean crops in different crop rotations under various cropping systems.
- Study major insects, predators, and parasites' life tables to build crop growth and insect development models and develop a forecasting system for sunflower with the collaboration of entomology research laboratory.
- Studying utilisation of cake and meal of oilseed crops in human diets and animal feed.

Priority 3

- Enhancing the process for developing inbred sunflower lines using tissue culture and other biotechnological methods with the collaboration of the tissue culture laboratory.
- Establishing electrophoresis techniques for the identification of inbred lines and tracing gene markers with the collaboration of the tissue culture laboratory.

Linkages and relationships. Within NARC, the oilseeds research programme will collaborate with on campus research programmes such as farm machinery institute, farming systems research programme, entomology research laboratory, crop diseases research institute, animal nutrition, food nutrition laboratory, soil fertility and social sciences programmes.

The oilseeds research programme collaborates with the following provincial research institutes: Oilseeds Research Institute, Faisalabad; Agricultural Research Institute, Tandojam; Agricultural Research Institute, Tarnab, Peshawar; Agricultural Research Station, D. I. Khan; and Agricultural Research Institute, Sariab, Quetta.

The programme also works with several national agencies—Ghee Corporation of Pakistan, Ministry of Industries, and Ministry of Food, Agriculture and Cooperatives—plus international organizations such as Crop Research Institute, Fundulea, Romania; FAO Sunflower Network, Bucharest, Romania; Institute of Agronomy, Pisa, Italy; Institute of Field and Vegetable Crops,

Novi Sad, Yugoslavia; Northern Crop Science Laboratory, North Dakota State University, USA; IDRC Oil Crops Network for East Africa and South Asia, Addis Ababa, Ethiopia; Asian Vegetable Research and Development Centre, Taiwan; International Development Research Centre, Canada; International Crop Research Institute for Semi-Arid Tropics, India; International Soybean Programme, USA; International Institute of Tropical Agricultural, Ibadan, Nigeria; and Agricultural Research Station, Agriculture Canada, Saskatoon, Canada.

Expected accomplishments

- World germplasm shall be obtained, characterized, and catalogued.
- Local sunflower hybrids shall be produced having resistance against diseases such as charcoal rot and collar rot for commercial cultivation in Pakistan.
- Near self sufficiency in edible oil will be achieved by planting of soybean and conventional oilseed crops in fallow fields in cotton, rice, riverine and barani areas.
- New production technology will be available for different agro-ecological zones for cultivation of soybean and conventional oilseed crops.
- Soybean and conventional oilseeds crops will be promoted for maximisation through demonstration of new production technology which will increase production of edible oil.
- Varieties found resistant to insect pests and major diseases will be utilized for breeding insect and disease resistance.
- Promiscuous lines of soybean will be made available.
- Varieties having low erucic acid and glucosinolate contents will be developed for commercial cultivation.
- Improved meal and cake will be utilized by the livestock and poultry industries.
- Production technology packages for non-conventional oilseed crops shall be worked out for target areas.

Sugar Crops

To close the gap between actual and potential production levels, sugarcane varieties need to be developed which can be successfully grown despite stresses like drought, salinity and waterlogging, poor soils, and frost. Varieties also need stronger resistance to diseases and insects. The development of high yielding, early maturing sugarcane varieties and better technology will enable farmers to increase their productivity and make sugarcane a more profitable crop. The major production problems are:

- Need for high yielding, disease- and stress-tolerant varieties adapted to major agro-ecological zones.
- Poor land preparation and planting methods and other agronomic practices which result in inferior stand establishment.
- Improper fertilizer and irrigation practices that result in low crop response to applied nutrients.
- Poor tilth and conservation practices which result in inefficient soil moisture use by crops.
- Excessive weed, and pest damage which depress crop yields.
- Post-harvest losses in production and sucrose content due to delayed supply to sugar factories.

Goals and objectives. The principal aims of the sugar crops programme are:

- To procure sugarcane and sugarbeet varieties and sugarcane fuzz from sugarcane-growing countries.

- To quarantine and conduct preliminary evaluation of imported material at NARC.
- To maintain a germplasm nursery at NARC and to multiply seed of selected cultivars and to distribute it to provinces.
- To coordinate national and international research activities.
- To conduct uniform variety trials and agronomic trials on sugarcane for evaluation of performance of sugarcane cultivars and develop packages of production technology.

Mandate. The mandate of the sugar crops unit is introduction, quarantine, and multiplication of new germplasm. Also the unit is responsible for maintaining sugarcane germplasm for further distribution and coordination with provincial research institutes, conducting trials and developing packages of production technology. The NARC is an ideal location for studies on imported germplasm since the centre is distant from the sugarcane-growing area.

Current programme. The sugar crops programme at NARC has responsibilities for acquiring and maintaining sugar crops germplasm. The coordinator of the national coordinated programme for sugar crops is based at NARC. The NARC group screens and evaluates germplasm from international sources. Early and medium maturing lines are needed and focus is on types tolerant to drought and frost. Agronomic studies and disease and insect pest studies are also being conducted. Sugarcane varieties are then distributed to other research organizations.

Proposed programme

Priority 1

- Acquisition, documentation and distribution of sugarcane germplasm for high yield, resistance to diseases and insect pests, and tolerance to frost, drought, and problem soils.
- Acquisition, documentation and distribution of sugarbeet germplasm for high yield, early maturity, and resistance to insects and diseases.

Linkages and relationships. On campus, the sugar crops project will require participation from agronomy, pest management project, Crop Diseases Research Institute, and agricultural economics. In working with the provincial centres, the dual assignment under which the national coordinator for sugar crops also serves as principal sugar crops investigator for NARC will be separated into two positions. The sugar crops unit at NARC will be an active member of the national coordinated programme and will conduct agreed-upon tests regarding sugar crops in the climatic zones of Punjab (Faisalabad), NWFP (Mardan) and Sind (Tandojam). The sugar crops project will also collaborate with centres where advanced research is in progress including biotechnology studies at universities, and Atomic Energy/Nuclear Institute for Agricultural Biology, etc.

The sugar crops unit at NARC, working with the plant introduction unit, will receive genetic materials from India, West Indies, USA, Indonesia, China, FAO, USAID and others. Some would be cane fuzz to be planted for screening and evaluation at NARC as well as by other cooperators within the national coordinated programme. Others would be potential parental lines for long-term preservation.

The NARC sugar crops team will be responsible for evaluating and selecting material for desired characters to meet national needs. It would also work with the plant genetic resources unit in increasing germplasm from time to time to assure that viable seed reserves are available.

Sugar crops projects will provide an important means by which farmers may validate improved sugar crops technology. Assessment will be in terms of increased productivity, net farm income and resource allocation changes.

Expected accomplishments

- Germplasm developed for better performance under different ecological conditions will raise average yield from about 37 t/ha to approximately 60 t/ha, raising total production by about 78,000 tonnes.
- The area under sugarcane will increase from 900,000 to 1,300,000 hectares as a result of germplasm which can do better under different ecological conditions and a shift in the planting date from February-March to September.
- Resistant varieties will lower the cost of production by about Rs 70/ha by eliminating the insecticidal input.
- The chemical control of weeds in sugarcane and sugarbeet will be simpler and more economical as a result of the development of crop genotypes which can tolerate the broad spectrum herbicides.
- Thousands of hectares subjected to salinity may be brought under sugarcane and sugarbeet by developing genotypes which could be successfully grown under these conditions.

Vegetable Crops

As the development of the country progresses, the rising demand for variety in diets is not being met. Vegetable crops are beset with different problems (diseases, pests, stresses etc.) The major production constraints are:

- Non-availability of quality seed of high yielding cultivars.
- Lack of suitable cultivars resistant to biotic and abiotic factors.
- Enormous insect and disease damage coupled with low plant protection coverages.
- Substantial losses prior to marketing.
- Paucity of market information such as price trends and fluctuations.

Goals and objectives. The principal aims of the vegetable crops programme are:

- To enhance production per unit area per unit time to increase per capita consumption and exports.
- To improve quality of the produce for better acceptance in local as well as foreign markets.
- To develop technology to minimize the production costs.

Mandate. The vegetable programme is to develop high yielding cultivars resistant to specific biotic and abiotic stresses through introduction and breeding, develop control methods for major pests and diseases, use biotechnology for crop improvement, and develop efficient methods to produce vegetables during periods of scarcity, and provide training.

Current programme. Evaluation, screening, and breeding for higher yields, disease resistance, stress tolerance of different vegetables are activities being carried out at NARC. Experiments on production of off-season vegetables and studies on various aspects are also being conducted.

Proposed programme

Priority 1

- Development of cost-efficient methods to produce off-season vegetables.
- Screening of onions for better shelf life, uniformity, quality, and higher yield.
- Use of growth regulators to enhance the storage life of onions.
- Identifying parents for F_1-hybrid seed production in tomatoes.

Priority 2

- Selection and breeding of chillies for resistance against *Phytopthora* species.
- Selection and breeding of tomatoes for shelf life, uniformity, quality, and higher yields.
- Development of seedless watermelons.
- Selection of peas for drought tolerance under barani conditions.
- Selection of peas for powdery mildew resistance.
- Popularizing techniques for spawn production and cultivation of edible mushroom.
- Research in seed production of crucifers.
- Development of mechanized sowing, transplanting, and harvesting devices for vegetables.
- Selection of tomatoes for biotic stress (heat) tolerance.
- Introduction of new vegetables.

Priority 3

- Development of suitable control measures for major local insect pests in vegetable crops.
- Ecological studies of major insect pests of vegetables at NARC.

Linkages and relationships. On campus the vegetable project shall require help from Crop Diseases Research Institute, soil science, tissue culture, cytogenetics and virology programmes. The programme will also have collaborative relations with University of Agriculture, Faisalabad, and NWFP Agricultural University, Peshawar. Internationally the project will have formal links with the Italian-funded project on fruit, vegetable and olive; the regional vegetable research project (includes Pakistan, China and DPR Korea); and International Agricultural Centre, Netherlands.

Expected accomplishments

- Phytophthora root-rot resistant, heat and drought tolerant cultivars of chilli will be produced.
- Cultivars of onion with better post-harvest quality and yield will be produced.
- Tomatoes with better post-harvest quality, resistance to TMV, TYLCV, and higher yield will be produced.
- Parents for F_1 hybrid seed production in tomato will be produced.
- Hybrids of tomato and cucumbers for plastic house cultivation will be produced.
- Cost-efficient greenhouses for off-season vegetable growing will be developed.
- Seed production technology of crucifers will be developed.
- Heat and drought tolerant tomatoes will be produced.
- Fusarium wilt and powdery mildew resistant pea will be produced.
- Varieties of cucurbits and crucifers for early maturity and higher yield will be produced.

Fruit Crops

Fruit growing is an agricultural enterprise which requires due care the year round. It demands considerable capital at the initial stages, but high returns can be achieved after several years. To improve production and quality, studies on agronomic, physiological, and genetic aspects, behaviour of different rootstocks and scion-stock interaction, use of growth regulators for specific purposes, vegetative propagation techniques for crops difficult to propagate, development of packages of production technology, introduction of non-conventional fruit crops, and development of technology to minimize post-harvest losses are essential.

The major production problems are:

- Need for high yielding cultivars.
- Need for introduction of non-traditional but promising fruit like pecans in the plains and lower hilly tracts.
- Poor cultural practices such as training and pruning in deciduous fruit trees.
- Improper fertilization and irrigation practices.
- Excessive weeds, insect pests, and diseases.
- Non-availability of quality nursery plants.
- Extensive post-harvest losses due to the acute shortage of cold storages and processing factories in the country.
- Inadequate fruit production technology packages.

Goals and objectives. The principal aims of the fruit crops production programme are:

- To enhance production to increase per capita consumption and export.
- To improve quality of the produce for better acceptance in the local as well as foreign markets.
- To develop technology to minimize production cost.

Mandate. The fruit crops programme is to standardize packages of production technology of important fruit crops, use biotechnology for crop improvement, standardize vegetative propagation techniques in guava, loquat, and other fruit plants, evaluate size controlling rootstocks and scion interactions in economically important fruit crops, standardize control methods for major fruit insects, pests, and diseases with germplasm adopted to different agro-ecological conditions of Pakistan, and provide training.

Current programme. The current fruit crops research programme involves maintaining germplasm of different fruit crops, screening and evaluating of low-chilling cultivars in deciduous fruits, selection of new rootstocks and conducting scion-rootstock interaction studies, use of growth regulators for specific purposes and studies in fruit entomology and pathology.

Proposed programme

Priority 1

- Introduction and evaluation of germplasm of loquat, guava, strawberry, citrus, and deciduous fruits with low chilling requirements.
- Studies on the asexual propagation of guava and loquat.
- Ploidy manipulation for crop improvement in guava and loquat.
- Histological studies on shoot tips to determine the initiation of bud dormancy in peach.

Priority 2

- Studies on rootstock and scion interaction in sweet orange, mandarin, peaches, etc.
- Nutritional studies in peaches, citrus fruits, and strawberry.
- Standardization of production technology for non-traditional fruit crops like kiwi fruit, strawberry, fig, etc.

Priority 3

- Studies on the post-harvest physiology of peach, citrus, guava, and strawberry.
- Physiological studies for different growth processes in peach, grapes, citrus, guava, and loquat.
- Breeding and cytogenetic studies in citrus and peach.
- Studies on the micro propagation of carnation and chrysanthemum.

Priority 4

- Studies on the establishment of high density orchards of peach and mandarin through various techniques.

Linkages and relationships. On campus, fruit programme shall require participation from tissue culture, cytogenetics, soil fertility, plant protection, farm mechanization, agricultural economics, and farming systems research programmes.

The fruit programme will collaborate with AARI, Turnab, and other Pakistani centres where site specific fruit research is in progress or where advanced research is in progress including biotechnology studies at universities, and Nuclear Institute for Agricultural Biology, etc. Internationally, the fruit programme will have formal linkages with the Italian-funded project on fruit, vegetables, and olive.

Expected accomplishments

- By introduction and evaluation of germplasm of different fruits, many well-adopted cultivars will be selected.
- Loquat and guava will be propagated asexually to get true-to-type plants for establishing uniform orchards. By ploidy manipulation, seedless guava and loquat will be created.
- Through physiological and histological studies, many problems will solved in fruit crops.
- Standard recommendations for production technology of fruits will be developed.
- By scion rootstock interaction studies, the best combinations of rootstock and scion will be selected, giving better quality and more yield in fruit crops.
- Heavy post-harvest losses will be reduced by new techniques of packing and cold storage.
- Breeding and cytogenetic studies will lead to good new cultivars.
- With micropropagation studies, conventional propagation methods will be replaced and better plants will be produced in less time.
- High density orchards, which are very economical and high yielding, will be established.

Seed Science and Technology

None of the research institutes or universities in Pakistan have an active programme on seed science and technology. Both at NARC and the provincial research centres, there is a strong emphasis on breeding for disease-resistant and stress-tolerant cultivars. But physiological, biochemical, and innovative technological approaches to improve seed quality and performance are totally lacking. There is no effective research programme to improve and upgrade seed testing procedures used to evaluate the quality and planting value of seeds.

The major problems in production of seed are:

- Quality of seed as affected by poor seed development, drying, and storage.
- Seed-borne diseases.
- Poor stand establishment of crops.
- Stress factors at the seedling stage.

A project entitled "Plant genetic resources preservation and Seed Science Institute" submitted by PARC has been cleared by Ministry of Planning. The project facilities will be funded by Japan International Cooperation Agency.

Goals and objectives. The principal aims of the seed science and technology programme are:

- To investigate seed quality problems encountered during seed development, drying,

processing, storage, transportation, and stand establishment.

- To improve the nutrition, size, shape, and germination of seeds and their performance in the field.
- To introduce modern seed technology including bioactive chemicals and to modify the physical seed environment to improve seed establishment under stress conditions.
- To identify soil-borne pathogens, parasitic activities, and the role of bioprotectants in alternative control measures.
- To elucidate ecological factors affecting crop seeds, weed-seed germination patterns and effect of soil environment on seed development.
- To establish a seed-testing quality reference control laboratory to support the national agricultural research system.

Current programme. At present some work on microbiology is being conducted at NARC to improve seedling establishment by altering the spermosphere and the rhizosphere. Some research on seed borne pathogens is being conducted by CDRI.

Proposed programme

Priority 1

- Determination of seed quality attributes and their relation with the field performance.
- Seed invigoration/stress alleviation in various crops through seed coating, seed pelleting, etc.
- Determination of factors contributing to the weed seed banks in agricultural soils.
- Maintenance and exchange of healthy seeds.
- Electrophoretic separation of isozymes for accession identification and as a genetic marker.

Priority 2

- Biological control of seed-borne diseases.
- Effect of temperature and moisture on seed longevity.
- Seed polymorphism, effect of photoperiod and thermoperiod on germinability and vigor of seed.
- Osmoconditioning of vegetable seeds to improve emergence and yield.

Plant Genetic Resources

The innumerable varieties of crop plants which have evolved over some 10,000 years of domestication constitute irreplaceable resources of genetic material. Innovative crop varieties and the introduction of high yielding varieties are rapidly transforming traditional and peasant farm lands into fields with uniform crops. The new varieties provide significantly higher yield or quality and have other beneficial characters bred into them. Unfortunately, when they replace traditional cultivars and land races, they quickly eliminate thousands of years of evolutionary development. Once a local traditional cultivar is totally displaced, its unique genetic characteristics are gone forever. Future generations are thus deprived of genetic variation, which is the raw material for breeding programmes. The major production issues are:

- Urgent need to enlarge the collection of indigenous genetic diversity through exploration of remote agro-ecological areas of Pakistan for cereal, legumes, oilseed, and other plants.
- Inadequate conservation facilities for seeds and vegetatively propagated material.

- Incomplete evaluation of conserved stock of the crop commodity programmes of NARC and provincial research institutes.
- Inadequate examination of incoming and outgoing germplasm to maintain healthy exchange of germplasm.
- Lack of published crop germplasm directories.

To safeguard valuable crop genetic resources, a national research project "Exploration, collection, conservation, evaluation and utilization of plant genetic resources" was started under the Pakistan Agricultural Research Council in 1977. This activity is part of a regional project on plant genetic resources, financed by Swedish International Development Agency and started under FAO, covering Afghanistan, Iran, Iraq, Syria, and Turkey, in addition to Pakistan.

Goals and objectives. The principal aims of the plant genetic resources programme are:

- Exploration of different areas of Pakistan to collect germplasm of cereals, food legumes, oilseeds, fruits, vegetable, etc.
- Characterization and preliminary evaluation of crop germplasm for agro-morphological and genetic traits.
- Conservation and preservation of germplasm under controlled temperature conditions.
- Establishment of a clonal repository (living genebank) for fruit crops.
- Documentation of genetic resources information for efficient retrieval and dissemination.
- Provision of genetic variability to breeders for crop improvement.

Mandate. Plant genetic resources is responsible for exploration, collection, conservation, preliminary evaluation, and documentation of all cultivated crops and their wild relatives. Because genetic variation is the basic tool for crop improvement, the mandate of the plant genetic resources unit is to supply crop germplasm to the user community within the country and abroad. Accordingly, to meet the needs of Pakistan's breeders and researchers, the unit also secures suitable germplasm from various international and national genebanks and research institutions. The unit is helping to form a global network of genetic resources units through exchange of genetic material and information.

Current programme. The plant genetic resources unit plans exploration and collection of crop germplasm in cooperation with the crop commodity coordinators. The unit has planned a biogeographic survey and collection of temperate fruit and nut species from the northern mountains of Pakistan, collection of lathyrus and small grain cereals from Sind and Northern Area, collection of fibre crops from Sind, Punjab, and Northern Area, collection of onion germplasm from NWFP and Baluchistan, and collection of lentil and faba beans from Baluchistan. The unit maintains about 14,000 accessions of cereals, food legumes, pulses, oilseed, vegetables, and fruit crops. Rice, wheat, barley, oat, lathyrus, millet, sorghum, *Agropyron*, *Elymus*, etc., are being evaluated and multiplied. The documentation of genetic resources information, e.g., passport data and evaluation data of wheat, is being computerized.

Proposed programme

Priority 1

- Conservation and maintenance of crop germplasm.
- Exploration and collection of crop germplasm.
- Preliminary evaluation and multiplication.
- Exchange and supply of germplasm.
- Documentation of crop genetic resources information.

Priority 2

- Detailed evaluation of crop germplasm.
- Cryopreservation, variation studies, and conservation of vegetatively propagated material.
- Collection and conservation of vegetatively propagated plants (clonal repository).

Advanced research. Specialized investigation includes cryopreservation, characterization using gel-electrophoresis, effect of moisture, temperature, and humidity on conservation of different crop seeds. Conservation of vegetatively propagated material through tissue culture, etc., will be studied.

Linkages and relationships. On campus, the unit collaborates with the coordinated research programmes in planning plant exploration and evaluating crop germplasm. It also collaborates with research laboratories on the campus in evaluation or screening of germplasm and with provincial research institutions and universities for collection, and evaluation of crop germplasm. The unit also supplies crop germplasm for utilization in crop improvement programmes.

The plant genetic resources unit collaborates with several international research centres in collection of germplasm and exchange of material and genetic resources information. Because there is no long-term storage facility in the country, the plant genetic resources unit places duplicate accessions at various international research centres.

Expected accomplishments

- The exploration of different areas and collection of crop germplasm will result in building a gene pool from which genetic material will be drawn for use in crop improvement.
- The characterization and evaluation of crop germplasm will help breeders to select appropriate genetic material for use in breeding programmes.
- Conservation and documentation will result in better availability of germplasm and more efficient retrieval of genetic resources information for efficient utilisation.

Plant Introduction Centre

Periodic disruptions in markets and weather make dependence upon a few crops risky. The introduction and development of new sources of food, feed, fuel and the development of new markets could greatly benefit the farmers. Differences in harvest schedules, storage requirements, and markets between new crops and traditional crops could give farmers valuable economic alternatives. Moreover many novel crops grow on marginal lands and require a minimum of inputs. The major production issues are:

- Insufficient exploitation of introduced plant species such as oilseeds, fibre crops, and varieties with tolerance to moisture or salt stress.
- Need for plant species suited for problem soils and resistance to major pests and diseases.
- Urgent need to exploit plant species suited to arid climates which could provide food, feed, protein, fibre and new sources of edible oil.

Goals and objectives. The principal aims of the plant introduction centre are:

- Identification and acquisition of exotic plant species with high economic value.
- Preliminary evaluation and documentation of initial performance characters.
- Plant germplasm distribution and documentation of its ultimate use.
- To gain knowledge and document new and improved chemical, biological, and agronomic potentials of selected plant species as sources of oil, wax, fibre, rubber, food, feed, fat, protein, and medicinal herbs.

Mandate. The unit is responsible for identification, introduction, and import of exotic plant species with high economic value, their acclimatization, and exploiting them for commercial cultivation in the country. The unit also attempts to meet the germplasm requirements of the scientists working in provinces, universities, and federal organizations.

Current programme. The plant introduction centre carries out research to improve and utilize underexploited plants and to monitor and coordinate research with provincial and federal research institutions in the country. During the last 5 years, it imported more than 3000 accessions of 68 plant species from 45 countries. The material was either evaluated at NARC or distributed to different research organizations. The emphasis has been on tropical legumes, horticultural plants, medicinal plants, edible oilseeds, and industrial oil-bearing plants. The unit functions as the focal point for incoming and outgoing germplasm and ensures the phytosanitary condition of the seed material.

Proposed programme

Priority 1

- Introduction of plants suitable for problematic soils and stress conditions.
- Introduction of plants bearing edible or industrial oil.
- Acquisition of germplasm, and post-entry quarantine.
- Documentation and exchange of germplasm.

Priority 2

- Introduction of food and feed legumes which are disease resistant and also provide fodder during lean periods.
- Introduction of new fruits and vegetables.
- Introduction of medicinal plants and spices.

Expected accomplishments

- Half of Pakistan's area is unsuitable for agriculture due to mountains, deserts, water logging, and salinity. If plants are selected for these particular ecologies, part of this area could be used for agriculture.
- Fodder plants which could support livestock during the lean periods will be introduced.
- New high yielding edible and industrial oil-bearing plants will be introduced from abroad.
- The germplasm of different crops will be provided to scientists to meet their demand for particular genotypes. Efforts will also be made to check the entry of any new disease that might be carried by incoming germplasm.

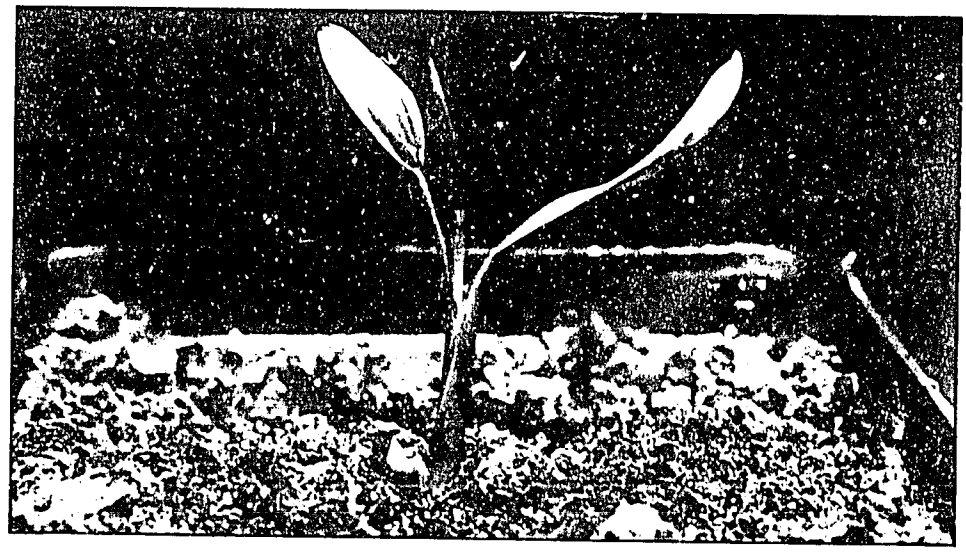
Tissue Culture

For overcoming certain factors that limit crop production, conventional plant breeding techniques are laborious and time consuming or are not applicable at all. Non-conventional methods like tissue culture, cell fusion, and gene transfer are useful adjuncts to plant breeding to accelerate or amplify the plant breeding process. The first area in which tissue culture technology had a distinct advantage over conventional breeding was the production of virus-free seed potatoes through meristem tip culture. Since then the spectrum of activities has broadened to include micropropagation of date palm and somaclonal variation in basmati rice and selected wheat cultivars. In addition, work is under way on tomato cultivars.

The issues affecting production are:

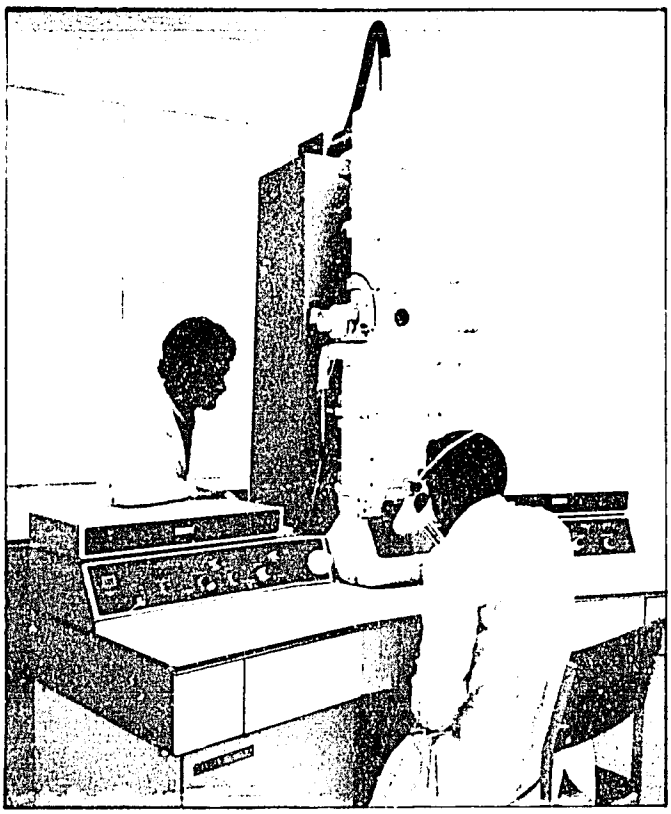
- Lack of information on virus control through meristem tip culture in vegetable and fruit crops.

Biotechnological advances enable NARC scientists to use tissue culture techniques to propagate dates and develop seedlings.



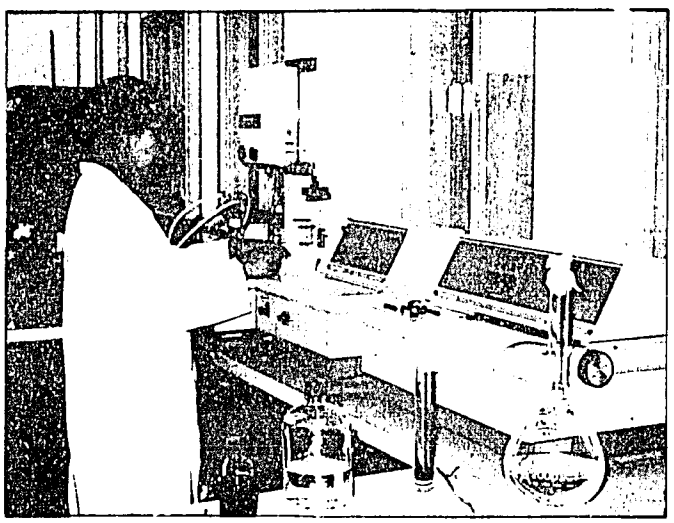
Date seedlings developed through tissue culture are transplanted into pots which enable NARC scientists to study growth and development of the dates raised from tissue culture.

The selection and propagation of superior datepalm trees is accelerated through tissue culture technology. The suckers produced in th laboratory besides being cheaper are easy to transport and would also promote exchange of high yielding datepalm varieties with other countries.

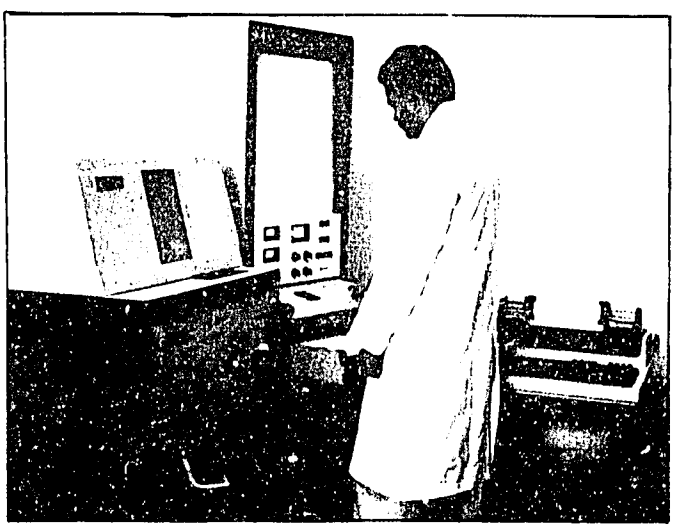


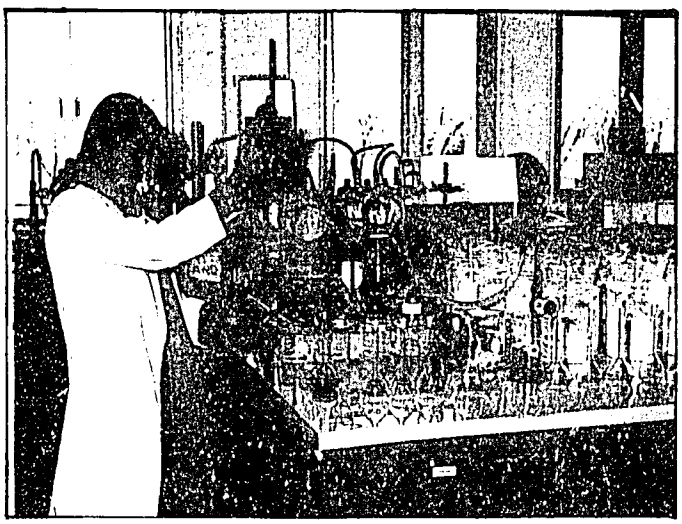
The solution of complex problems often require modern sophisticated equipment. Scientists are examining a virus strain under the electron microscope.

Mass spectographs and flame photometry are analytical tools used in the soil science laboratory to determine micronutrient status of soil and plants.



The identification of clay mineralogy through use of the X-ray diffraction equipment assists scientists to understand fertilizer reactions in the soil.





Extraction of oils, protein and other plant constituents require modern facilities for precision analysis. Female scientists at NARC are important members of the research staff.

- Urgent need for micropropagation of selected horticultural crops.
- Insufficient use of tissue culture in resolving problems of stress (salinity, diseases, drought, etc.) in major cereals and varietal improvement through anther/pollen culture in cereals and oil crops.
- Widespread somaclonal variation/disease resistance in horticultural crops.
- Unrealized opportunity for tissue culture use in somatic hybridization and genetic transformation.

Objective and goals. The principal aims of the tissue culture programme are:

- Establishment of micropropagation procedures in selected horticultural crops.
- Virus elimination in fruits and vegetables through meristem tip culture.
- Somaclonal variation.
- Screening stress in major cereal crops (salinity, drought, diseases).
- Expansion of research to oilseed crops.
- Varietal improvement through anther culture.
- Selection at cellular level for major crops.
- Regeneration of whole plants from cell culture and protoplasts.
- Somatic hybridization through protoplast culture.
- Isolation and identification of genes for important agronomic traits, their cloning in suitable vectors and transformation through physical or vehicle-mediated techniques.

Mandate. The mandate of the tissue culture unit is to conduct research in areas which are either deficient or lacking at the provincial level. Training of scientists from other institutes is also an important mandate of the council.

Current programme. The current programme focuses on date palm and rice and wheat. In date palm, research efforts are directed to obtain synchronized microshoot formation in the cultivar Dhakki and its transference to pots. Isozyme assays to determine the clonal nature of regenerated plantlets will be conducted simultaneously. Rice lines originated through tissue culture are being field tested in rice-growing areas at Kala Shah Kaku and saline areas at Sadhoke. Meanwhile, conditions are being monitored to maintain cell suspension cultures. Basic studies are also under way to study the proteins synthesized by calli under stress conditions. High frequency, embryogenic callus induction and its subsequent regeneration in a number of wheat cultivars is being investigated. Material is nearly ready for field testing. In addition the tomato cultivar "Roma" is being used in studies that aim to obtain virus-free and disease-resistant lines. All this work is supported by strong cytological back up from the vegetable programme.

Proposed programme

Priority 1

- Pre-basic seed production through micropropagation and new approaches like in-vitro tuberization and somaclonal variation.
- Somaclonal variation in wheat and rice through embryo and anther culture.
- Micro propagation in date palm.
- Virus elimination or disease resistance in selected horticulture and vegetable crops.
- Identification of cellular proteins and messengers involved in embryogenesis and stress tolerance.
- Cell culture and protoplast cultures.

Priority 2

- Cell fusion.

- Development of physical transfer techniques and vectors for genetic manipulation.
- Isozyme analysis to evaluate the marker system.

Advanced research. Beside routine micropropagation, somaclonal variation and virus eradication the efforts of the unit are also geared to more complex problems of basic research, e.g. understanding the nature of proteins associated with embryogenic calli both under stress conditions and without any stress in cereals, and standardizing the techniques of a reproducible regeneration system from cell/protoplast culture. Recently, the suspension culture techniques are being standardized. The work will pave the way for future genetic engineering studies on the return of scientists of the programme who are engaged in Ph.D. programmes abroad.

Linkages and relationships. On campus, the unit works closely with coordinator wheat, coordinator rice, coordinator horticulture, coordinator potato, plant pathology, virology, salinity group, and soils group. Training programmes have been conducted for the Pak-Swiss Potato Project, Islamabad; FAO/UNDP Seed Potato Project, Gilgit; Punjab Seed Corporation, Sahiwal; and Seed Potato Project, Abbottabad.The unit has professional contacts with CIP (Lima), IRRI (Los Banos), CIMMYT (Mexico), and TCCP (Colorado State University, USA) and University of Nottingham, U.K.

Expected accomplishments

- The technology for pre-basic seed production through micropropagation and new approaches like in vitro tuberization and somaclonal variation will be disseminated to public and private agencies.
- A micro-tuber technology for pre-basic seed potato production will be introduced.
- In wheat and rice, field evaluation and selection of somaclones and stress-tolerant lines obtained through tissue culture using seed as the explant source.
- In wheat and rice, regeneration from anther and pollen culture will be established, reducing the time and cost for expanding the genetic pool.
- In date palm, reproducible micropropagation systems will be established through somatic embryogenesis.
- Quality control tests through isozyme analysis and restriction fragment length technique (RFLP) will be performed with micro-propagated date palm.
- Tissue culture will be used for virus elimination and improved disease resistance in selected horticultural crops identified by concerned commodity programmes.
- Cellular proteins and messenger RNA's involved in embryogenesis and stress tolerance will be identified.
- A cell culture system in selected cereals and horticultural crops will be established to use as a tool for screening.
- A protoplast system for genetic manipulation will be established.
- Conditions of regeneration from cells/protoplasts in selected cereals/horticultural crops will be standardized.
- Conditions for somatic hybridization in horticultural crops and cereals will be standardized.
- Physical transfer techniques or vectors for genetic manipulation will be developed.
- Various isozyme sequences will be studied to evaluate their significance in identification of variations in crops under study.

Cytogenetics

Chromosome manipulations are established techniques employed in plant breeding, horticulture, and many other disciplines of life sciences. Alien genetic transfer is useful with crops whose genetic resources for disease resistance are either depleted or have become scarce because

new races of the pathogens are rendering the resistance sources ineffective (resistance of wheat to rust, for instance).

Species introgression between closely related species within a genus such as *Brassica* is another useful application of cytogenetic procedures. Such an approach does not drastically reduce the vigor of the hybrids as compared with the more distant crosses in wheat.

Introduction of polyploidy can improve the quality of fruits. In floriculture this technique can be applied to increase the size and thus the ornamental value of plants.

Goals and objectives. The principal aims are:

- Chromosome manipulation for crop improvement.
- Developing collaborative research at the national and international level.
- Introducing and strengthening cytogenetic research in provinces.
- Offering research facilities to post-graduate students.

Mandate. The mandate of this programme is to use cytogenetic techniques for the improvement of crop plants. The programme also helps strengthen cytogenetics research in the provincial research establishments by offering training courses and organizing workshops, symposia, interacts with the universities by offering research facilities for postgraduate students, and develops collaboration at national and international levels.

Current programme. Research of different types is underway involving wheat, brassica, grasspea, and tea. Because of its ability to tolerate loss or gain in its chromosome complements, bread wheat is one of the most favourable materials for alien genetic transfer. Several hybrids have been reported between *T. aestivum* and its distant relatives. Among the possibilities are transferring leaf rust resistance from rye into wheat or transferring salt tolerance from *Agropyron junceum* into wheat. Several techniques such as protoplast fusion and DNA transfer are now becoming available for alien genetic transfer in some plant species. At present, however, conventional, chromosome manipulation procedures are the best options. The cytogenetics programme has, therefore, collected material from various sources to provide a sound base for wheat experiments started in Rabi 1987-88.

Rape and mustard are the most widely cultivated oilseed crops which are members of the genus *Brassica*, a polyploid complex having several cultivated species with different chromosome numbers. Desirable characters such as absence of erucic acid and glucosinolate, resistance to aphids with high yield potentials, non-shattering, or early maturity can be found individually in certain *Brassica* oilseeds, but not in combination. Interspecific hybridization could integrate all these traits into one plant. Such a plant could eventually give rise to a desired oilseed crop. Several interspecific hybrids have been grown in this group by Dr. Qazi Hanif of NWFP Agricultural University, Peshawar. NARC scientists have studied the cytology of F_1s and have established their hybrid nature. A significant achievement was evidence of genetic introgression between A, B, and C genome in a hybrid between *B. juncea* and *B. carinata*.

Grasspea (*Lathyrus sativus*), because of its ability to withstand drought and flood, has been cultivated throughout history for fodder and seed. It is grown extensively in the Rice Canal area of Sind. The nutritional value of the seed is high, however consumption of large amounts causes paralysis of lower limbs. *L. cicera* x *L. sativus* and *L. amphicarpus* are the only interspecific hybrids obtained which involve the grasspea. The latter hybrid shows agronomic characteristics such are resprouting which could be exploited for developing a multiple harvesting crop. The programme has collected seeds of several species in the genus and will attempt to obtain hybrid combinations which could be useful for the improvement of this indigenous crops.

In tea, seed sterility is a desirable because it increases the vigour of the plant. Production of triploids is one of the means readily applicable to tea for evolving a seedless plant. Determination

of chromosome number in a Chinese variety of tea grown at Mansehra has revealed its diploid nature. Experiments are planned to induce tetraploidy through colchicine treatment. Induced tetraploids will then be crossed with the diploids to obtain triploids. Vigorous triploids will propagate vegetatively through cuttings.

Proposed programme

Priority 1

- Alien genetic transfer for rust resistance and tolerance in wheat.
- Species introgression for improved economic characteristics in *Brassica*.

Priority 2

- Interspecific hybridization for high yield and toxin-free grasspea.
- Induction of sterility in tea for better vigour.
- Developing seedless fruits through polyploidy for improved quality.

Advanced research. Advanced research will involve identification of individual chromosome and chromosome segments through chromosome banding; identification of genetic material through various separation techniques (e.g. electrophoresis); assignment of genes to the individual chromosomes through trisomic, monosomic, nullisomic, and telocentric lines; production of large numbers of haploids through *bulbosum* techniques; utilization of tissue-culture techniques for the production of haploids, somatic hybrids, and propagation of sterile hybrids; cytogenetics of fruit trees and ornamentals; insect and animal cytogenetics and gene manipulation through innovative techniques.

Linkages and relationships. The main collaborating organizations are, on campus, horticulture programme, plant genetic resources, and the BARD project; NWFP Agricultural University, Peshawar; Tea Project Mansehra; and AEARC, Tandojam.

Expected accomplishments

- In work on more than 50 hybrid combinations both at the diploid and polyploid level, hybrid derivatives from the primary crosses should be in advanced stages to be evaluated for their agronomical characteristics. Introgression of the desired genetic traits is expected to be accomplished and some of the materials will probably be ready for release as varieties after going through uniform national yield trials. More germplasm, however, will be added from time to time to expand the experiments and to maintain the continuity of the process so as to have a vast collection of genetic diversity suitable for the future needs of the country.
- Distant hybrids between wheat and its allied species and within or between related genera will be obtained. Amphiploids and back-cross progenies will be evolved from some of these hybrids, depending on the genome interaction in the alien environment. Recurrent selection for desired traits will be done which should result in the evolution of useful breeding material.
- New hybrid combinations in grasspea will be attempted and it is hoped that additional interspecific hybrids will be obtained. Cytogenetics investigation will be carried out to evaluate the usefulness of the hybrids in the breeding programme. Synthetic polyploids will be obtained and, depending on the fertility of the material, crossing at the polyploidy level will be attempted. Hybrid derivatives thus obtained will be compared with the other materials. It is also hoped that a complete collection of the germplasm in the genus will be obtained and maintained at NARC.
- Several cultivars of tea will be treated with colchicine to obtain autotetraploids. The autoploids thus obtained will be crossed with their diploid parents to obtain

triploids. These triploids will be evaluated for their agronomical characteristics. This material should show a considerable degree of desired sterility.

Food Technology

Unbalanced agricultural production leads to three forms of nutritional deprivation: (i) Inadequate food intake creates the primary problem of extensive undernourishment, (ii) the extra nutritional needs of infants, pre-school children and pregnant and lactating mothers are not adequately met, and (iii) some dietary patterns result in deficiencies of micronutrients like vitamin A, iron, and iodine. It is well established that malnutrition lowers the disease resistance of children 1- to 5-years old and raises their mortality rate. It retards mental and physical development, lowers productivity, and reduces the span of work years. All of these conditions significantly influence the economic potential of an individual.

Poverty and undernutrition are the twin causes of malnutrition in the rural areas of developing countries. In the past, the approach has been to maximize the production of goods and services. Now there is growing realization among planners that economic growth as measured by GNP does not effectively deal with the problem. At this moment, the resources committed to agricultural development do not have a manifest beneficial effect on nutrition, and any effect that they do have is more by chance than intention. This consideration has prompted increasing demand for the introduction of nutritional consideration into agricultural development programmes.

Major problems related to food technology are:

- Degradation of nutritional quality by increasing the yield of food crops.
- Variation in quality of food crops with production environment.
- Changes in the nutritional, cooking, milling, and baking quality that occur during storage of food crops.
- Methods of processing affect the nutritional quality of foods and consumers' acceptance.
- Presence of toxic elements in food ingredients.
- Antinutritional factors in some crops.
- Lack of methods for utilizing cheap raw materials.
- Lack of information on the composition of Pakistani food crops.
- Lack of nutritional data on diets in different parts of the country.

Goals and objectives. The principal aims of the food technology programme are:

- To screen food crop varieties for nutritional quality and consumer acceptance.
- To identify and resolve nutritional problems of selected crops and provide facilities and service support to the national agricultural research system.
- To strengthen linkages between national and international institutions in developing collaborative research to solve priority food and nutrition problem and provide training workshops, etc.
- To provide analytical services to the plant and animal scientists working in provincial institutions.

Mandate. The mandate of the programme is to conduct quality research on food and nutrition problems as related to agriculture in Pakistan, to provide service support to the national agricultural research system, to strengthen the linkages with national and international institutions, and to provide analytical services to the plant and animal scientists working in the provinces.

Current programme. The programme screens germplasm of cereals, legumes, and oilseeds

for nutritional quality and consumer acceptance. It also studies the anti-nutritional factors in cereals and legumes and the effect of production environment on the nutritional quality and consumer acceptance of cereals, food legumes, and oilseeds. Work on development of new food products from soybean and the improvement of the digestibility of food legumes is also being carried out. The study of trace element content and pesticide residues in food products is another important area of current research activity.

Proposed programme

Priority 1

- Screening of germplasm, advanced lines, and varieties of cereals, legumes, and oilseeds grown in different agro-ecological zones for nutritional quality and consumer acceptance.
- To produce more bread from less wheat by using traditional cereals for partial replacement of wheat.
- Nutritive value of traditional chickpea products consumed in Pakistan.
- Effect of storage on nutritional quality and consumer acceptance of legumes, fruits, and vegetables.

Priority 2

- Nutritional evaluation of diets in different agro-ecological zones.
- Effect of production environment on the nutritional quality and antinutritional factors in legumes.
- Effect of processing (soaking, germination, cooking, baking, milling etc.) on the nutrient losses, technological value, and nutritional quality of cereals and legumes.
- Quality evaluation of new varieties of vegetables and fruits.

Priority 3

- Determination of the levels of nitrate, nitrite, and nitrosamines in vegetables, meat, and milk.
- Effect of national agricultural policies on the nutritional status of the local population, using standard survey methodology (FAO).

Advanced technology. Advanced technology will involve making use of the physical facilities at NARC and, drawing on the capabilities of scientists with special expertise, this programme should concentrate on development of novel food products (weaning foods, soy foods etc.) from cheap raw material, development of improved quality bread and chappati, and upgrading the quality of food products both for domestic and export markets.

Linkages and relationships. On campus, the programme will require collaboration from the wheat, rice, maize, sorghum, millet, food legumes, oilseeds and BARD programmes and the gene bank. The programme provides analytical services and training facilities to the following provincial research centres and universities: Ayub Agricultural Research Institute, Faisalabad; Plant Breeding and Genetics Department, University of Agriculture, Faisalabad; Nuclear Institute for Agricultural Biology, Faisalabad; Maize and Millet Research Institute, Yousafwala; Food Department (Government of Punjab), Lahore; Hill Fruit Research Station, Murree; Agricultural Research Institute, Tandojam; Atomic Energy Agriculture Research Centre, Tandojam; Cereal Crops Research Institute, Pirsabak; and Agriculture Research Institute, Quetta. The programme also provides analytical services and technical advice to the following federal institutions: National Seed Registration Department, Food and Agriculture Division; Food Industries; Pakistan Agricultural Prices Commission; National Institute of Health; and Quaid-e-Azam University, Islamabad.

The programme will conduct collaborative research with IRRI on rice quality, ICARDA on

lentil quality, University of Nebraska, on the effects of production environments on technological value and nutritional quality of wheat grain and with CIMMYT on evaluation of wheat varieties for chappati. The food technology and nutrition programme shall continue to provide training facilities to provincial scientists and post-graduate students from agriculture universities and colleges of home economics, etc.

Expected accomplishments

- Data on nutritional quality and consumer acceptance of food crops will be compiled and analysed.
- The effect of the production environment on nutritional quality will be better understood.
- Toxic effects of nitrate, nitrite, and nitrosoamines of common foods in Pakistan will be assessed.
- Methods will be developed to improve the shelf life and quality of bread by the use of emulsifiers, preservatives, etc., and also to replace a part of the wheat in bread by other commodities, e.g., soy flour, maize, potato, etc. so as to reduce the pressure on wheat and to improve the nutritive value of bread.
- The effect of storage on nutritional quality of cereals, legumes, oilseeds, and their products will be assessed.
- Food products (weaning food, soyfood etc.) will be developed from cheap raw materials.
- The effect of national agricultural policies on the nutritional status of the local population will be evaluated.
- Pesticide residues in cooked food products will be measured.
- Effect of processing (soaking, germination, cooking, baking, milling, etc.) on the quality of cereals, legumes, oilseeds, and vegetables will be assessed.
- The quality of vegetables and fruits will be evaluated.
- Nutritional content of diets consumed in different agro-ecological zones will be evaluated.
- Novel food products will be developed from cheap raw material such as cottonseed cake.

RESOURCE REQUIREMENTS: CROP PRODUCTION

WHEAT, BARLEY, TRITICALE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Development, introduction, evaluation and distribution of germplasm.	1	1.5	70000	1.5	95000	1.5	125000	1.5	150000	1.5	170000	1.5	250000
2. Multilocation testing (NUWYT) and evaluation.	1	1.0	50000	1.0	80000	1.0	100000	1.0	125000	1.0	140000	1.0	225000
3. Development of high yielding disease resistant varieties for rainfed situation & problem soils.	1	0.5	30000	0.5	55000	0.5	75000	0.5	100000	0.5	115000	0.5	150000
4. Develop improved cultural practices for the barani wheat based cropping patterns through on-farm work	1	3.0	60000	3.0	105000	3.0	140000	2.5	145000	2.5	165000	2.0	150000
5. Develop/use computer simulation models as a tool for crop management research.	1	2.0	35000	2.0	65000	2.0	85000	2.5	140000	3.0	150000	3.0	220000
6. Diversification of the genetic base of rust resistance in commercial wheats.	1	1.0	30000	1.0	55000	1.0	75000	1.0	100000	1.0	120000	1.0	170000
7. Individual cell level screening for disease resistance.	1	-	-	-	-	0.5	25000	0.5	50000	1.0	70000	1.0	135000
8. Study, develop and use of efficient breeding methodology.	2	0.5	20000	0.5	35000	0.5	50000	0.5	80000	0.5	100000	0.5	130000
9. Use of haploid doubling for accelerating variety development.	2	-	-	-	-	0.5	25000	0.5	50000	0.5	70000	1.0	125000
10. Study of wheat multilines and mixtures.	2	-	-	0.5	20000	0.5	35000	0.5	60000	0.5	75000	0.5	100000
11. Interspecific and intervarietal hybridization for obtaining a quantum jump in yield.	2	-	-	0.5	20000	0.5	35000	0.5	60000	1.0	85000	1.0	110000
12. Development of wheat hybrid tech. and heterotic pattern identification.	3	-	-	-	-	1.0	30000	1.0	50000	1.0	65000	1.0	90000
13. Develop techniques for studying multiple wheat based crop systems.	3	1.0	15000	1.0	28537	1.0	45108	1.0	72504	1.5	105604	2.0	242360
14. Development of wheat (Durum) that suit export requirements.	3	0.5	6000	0.5	10000	0.5	20000	0.5	3000	0.5	40000	1.0	80000
Total		11.0	316000	12.0	568537	14.0	865108	14.0	1185504	15.0	1470604	17.0	2177360

BUDGET							
	Staff Costs: Existing (1988/89 + 3%/year)	1709472	1760756	1813579	1867986	2466155	3610698
	Additional	0	0	0	0	173500	229772
	Operational Funds	316000	568537	865108	1212504	1470604	2177360
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	2025472	2329293	2678687	3080490	4110259	6017830

* Number of scientists (BP 17-20) 1 PSO, 6 SSO, 8 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

MAIZE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Development and evaluation of maize germplasm for tolerance to drought and cold using genetic, chemical and physiological diversity in field and laboratory investigation.	1	2.0	62000	2.0	100000	2.0	142000	2.0	152000	3.0	162000	3.0	350000
2. Application of hectrochromatic knob composition in predicting combining ability & tolerance for inbreeding depression in maize.	1	2.0	62000	2.0	98000	2.0	142000	2.0	152000	2.0	156000	2.0	190000
3. Modelling, verification and demonstration of input levels for economical cultivation of maize under barani conditions through FSR activities.	1	1.0	31000	1.0	50674	1.0	71432	1.0	76783	1.0	81675	1.0	95000
4. Biological parameters related to host plant resistance in maize varieties against Chilo partellus.	2	1.0	31000	1.0	48000	1.0	71000	1.0	76000	1.0	78000	2.0	116458
5. Evaluation of row vs. broadcast planting in maize intercropped with legume fodders at different densities & fertilizer levels under barani conditions.	2	-	-	-	-	-	-	1.0	76000	1.0	78000	1.0	95000
6. Evaluation of maize populations containing different proportions of exotic & adapted germplasm.	3	-	-	-	-	-	-	-	-	-	78000	1.0	95000
Total		6.0	186000	6.0	296674	6.0	426432	7.0	532783	8.0	633675	10.0	941458

BUDGET									
	Staff Costs: Existing (1988 + 3%/year)	689784	710478	731792	753746	1066329	1561212
	Additional	0	0	0	45429	77211	99350
	Operational Funds	186000	296674	426432	532783	633675	941458
	Total (1988 + 15%/year)	875784	1007152	1158224	1331958	1777215	2602020

* Nuber of scientists (BP 17-20) 2 SSO, 4 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

RICE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Basmati varietal improvement through innovative means, develop direct seeding tech. and screening germplasm for biotic and abiotic stresses resistane	1	3.0	110000	3.0	190000	3.0	210000	3.0	280000	4.0	350000	4.0	480000
2. Genetic and inheritance studies for pest resistance and quality parameters of rice varieties through incorporation of desirable genes.	1	2.0	65000	2.0	80000	2.0	160000	2.0	230000	3.0	200000	3.0	350000
3. Effect of different rice based cropping systems and cultural practices on carry-over of insect pests, their natural enemies and rice agro-eco-systems.	1	2.0	45000	2.0	46565	2.0	86291	2.0	94930	3.0	148253	3.0	220545
4. Physiochemical characterization and fertility management of rice soils for high productivity and fertilizer use efficiency.	2	2.0	50000	2.0	93594	2.0	130000	2.0	180000	2.0	220000	3.0	350000
5. Effect of environmental plant stresses on the level of resistance against insect pests and their relationship with host plant which can be used as selection markers in breeding resistance varieties.	2	3.0	55000	3.0	95000	3.0	150000	3.0	180000	4.0	210000	4.0	300000
6. Studies on storage conditions, environmental factors and cultural practices that influence rice grain quality. Assessment of post-harvest losses and develop rapid and simple techniques to evaluate rice grain quality.	2	1.0	35000	1.0	80000	1.0	120000	2.0	160000	2.0	200000	2.0	290000
7. Determining bottlenecks and assessment of socio-economic implication of new technology and identifying practical means for their adoption.	3	1.0	30000	1.0	70000	1.0	100000	1.0	160000	1.0	200000	1.0	280000
Total		14.0	390000	14.0	655159	14.0	956291	15.0	1284930	19.0	1528253	20.0	2270545

BUDGET													
	Staff Costs: Existing (1988/89 + 3%/year)		1722156		1773821		1827035		1881846		2571699		3765225
	Additional		0		0		0		45549		186213		239605
	Operational Funds		390000		655159		966291		1284930		1528253		2270545
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)		2112156		2428979		2793326		3212325		4286165		6275375

* Number of scientists (BP 17-20) 2 PSO, 6 SSO, 6 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SORGHUM AND MILLET: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Colllection, evaluation and conservation of local sorghum germplasm in collaboration with PGR unit of NARC.	1	0.25	20000	0.25	30000	0.25	35000	0.4	40000	1.0	40000	1.0	50000
2. Development of high yielding dual purpose (grain cum forage) varieties.	1	0.5	30000	0.5	45000	0.5	50000	0.6	54000	1.0	55000	1.0	70000
3. Screening of the local and exotic germplasm and segregating generations of crosses for the tolerance to stress conditions, particularly tolerance to drought, heat, salt and emergence through crusted soil surface.	1	0.25	18000	0.25	25000	0.25	30000	0.4	30000	0.4	30000	1.0	45000
4. Development of hybrid/composites of sorghum and millet.	1	0.3	18000	0.3	25000	0.3	30000	0.4	35000	0.8	35000	1.0	50000
5. Testing of national and international germplasm in observation nurseries/replicated trials.	1	0.3	20000	0.3	30000	0.3	30000	0.4	35000	0.8	35000	0.5	45000
6. Evolution/development of sorghum varieties having stay green character and better bio-mass production.	1	0.2	15000	0.2	25646	0.2	25000	0.4	25000	0.3	26000	0.5	33000
7. Demonstration of improved/verified production technology through on-farm and FSR trials and simultaneously work-out economics of these crops.	1	0.2	10000	0.2	15000	0.2	15000	0.4	18000	0.4	20000	0.5	38000

continued

SORGHUM AND MILLET (continued)

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
8. To conduct survey to determine which diseases and pests are causing the greatest losses to sorghum and millet crops and to breed for resistance to major diseases and pests.	2	-	-	-	-	0.3	16448	0.25	18508	0.3	20281	0.5	30616
9. Studies on intercropping, weed control, sowing dates, fertilizer use and plant population for sorghum and millet varieties.	2	1.0	38000	1.0	40000	0.7	40000	0.25	45000	0.5	50000	1.0	80000
10. Mechanization of sorghum and millet production with regard to tillage operation, plant stand establishment, use of drill in sowing and use of machines for harvesting and threshing in collaboration with FMI.	2	-	-	-	-	-	-	0.5	55000	0.5	60000	1.0	110000
Total		3.0	169000	3.0	235646	3.0	271448	4.0	355508	5.0	371281	8.0	551616

BUDGET								
Staff Costs: Existing (1988/89 + 3%/year)	344136	354460	365094	376047	624779	914739
Additional	0	0	42080	48861	45239	58211
Operational Funds	169000	235646	271448	355508	371281	551616
Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	513136	590106	678622	780416	1041299	1524566

* Number of scientists (BP 17-20) 1 PSO, 2 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

FODDER CROPS: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Collection, screening, evaluation, distribution an maintenance of exotic and indigenous germplasm of fodder crops in collaboration with PIC and PGR.	1	1.0	8000	1.0	25000	1.0	30000	0.5	40000	0.6	45000	1.0	65000
2. Determination of effect of mechanized fodder production using improved fodder production technology on the milk and meat production in collaboration with FMI and ASI.	1	1.0	20000	0.5	30000	0.5	35000	0.5	45000	0.6	50000	1.0	70000
3. Determination of exact proportion of supplementation of dry fodder by green fodder of different types and its implication on the economical production of milk and meat in collaboration with ASI.	1	0.6	14000	0.5	23048	0.5	25398	0.5	35000	0.6	45000	1.0	65000
4. Breeding for development of drought, disease and cold tolerant fodder varieties of high nutritive value, with special emphasis on problem soils and marginal lands.	1	0.4	9000	0.5	20000	0.5	30000	0.5	40000	0.6	50000	1.0	70000
5. Evaluate, promote multicut and new high yielding fodder varieties to develop year-round supply of green fodder and cover fodder deficit periods to improve animal production system in the country.	1	0.5	9000	0.5	20000	0.5	30000	0.5	40000	0.6	50000	1.0	70000
6. Determine flexibilities in fodder production in different agro-ecological zones through agronomic/management practices of sowing dates, cutting heights and fertilizer application.	1	0.5	8000	0.5	20000	0.5	30000	0.5	40000	0.6	50000	1.0	70000

continued

FODDER CROPS (continued)

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
7. Fitting of improved fodder varieties in different farming systems and cropping patterns through on-farm research to develop efficient fodder - live-stock production system under different agro-ecological zones.	2	-	-	0.5	30000	0.3	30000	0.4	32000	0.6	45000	0.5	60000
8. Quality determination for crude protein, crude fibre etc. including minerals of economic importance and against toxicities through laboratory analysis, feeding trials in relation to stage of cutting in the promising varieties of different fodder crops.	2	-	-	-	-	0.2	10000	0.2	14000	0.3	32223	0.5	50000
9. Determine hay making and silage options for surplus fodder production and see its effect in terms of a package on the income derived through increased production of livestock by-products.	3	-	-	-	-	-	-	0.3	20000	0.3	30000	0.5	50000
10. Conduct of BNF studies on fodder legumes and determine its effects on the growth and yield of cereal crops in collaboration with BNF program.	3	-	-	-	-	-	-	0.1	10951	0.2	20000	0.5	39231
		4.0	68000	4.0	138048	4.0	180398	4.0	240000	5.0	290000	8.0	410000

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	498732	513694	529105	544978	690036	1010282
	Additional	0	0	0	0	42801	64291
	Operational Funds	68000	138048	220398	316951	417223	
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)						

* Number of Scientists (BP 17 - 20) 1 PSO, 3 SO.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

PULSES: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Evaluation of germplasm material of chickpea, lentil, mung and mash for characters like high yield, short duration, drought tolerance and disease resistance.	1	4.0	30000	4.0	50000	3.0	90000	3.0	150000	3.0	220000	3.0	385322
2. Breeding of chickpean, lentil, mung and mash for development of high yielding varieties with desirable characters.	1	3.0	25000	3.0	60000	3.0	100000	3.0	160000	3.0	230000	3.0	400000
3. Studies on improved agronomic practices which can provide effective weed control, high plant densities and positive response to high inputs with special reference to rhizobium and fertilizer use.	2	2.0	30000	2.0	75000	2.0	110000	2.0	180000	3.0	220000	3.0	280000
4. Introduction of improved production technology for raising small farm, farmers' income with pulses production in the barani areas through FSR program.	2	2.0	25000	2.0	85000	2.0	90615	2.0	125000	2.0	230413	3.0	280000
5. Studies on race spectrum of chickpea blight caused by Ascochyta rabiei.	3	1.0	10000	1.0	35000	1.0	75000	1.0	100613	1.0	126000	1.0	180000
6. Studies on use of Bacillus thuringenesis (B.T) for the control of chickpea pod bores.	4	2.0	15000	2.0	31111	2.0	77000	2.0	90000	2.0	120000	2.0	150000
7. Evaluation of germplasm of new pulse crops like pigeonpea, cowpea and common beans for high yield, disease resistance and other economic important characters.	4	-	-	-	-	1.0	30000	1.0	45000	1.0	80000	1.0	90000
Total		14.0	135000	14.0	336111	14.0	572815	14.0	850613	15.0	1226413	16.0	1765322

BUDGET	Staff Costs: Existing (1988/89 + 3%/year)		1507176		1552391		1598963		1646932		1999465		2927417
	Additional		0		0		0		0		106564		186290
	Operational Funds		135000		336111		572815		850613		1226413		1765322
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)		1642176		1888502		2171778		2497544		3332442		4879029

* Number of scientists (BP 17-20) 2 PSO, 3 SSO, 9 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

OILSEEDS: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Evaluation and screening of germplasm of mandate oilseed crops, rapeseed-mustard, groundnut, sunflower, soybean and safflower for selecting desired genetic sources for different agronomic traits and disease, insect, drought resistance, to develop high and sustainable productivity.	1	1.0	75000	1.0	100000	1.0	115000	1.0	135000	1.0	135000	1.0	200000
2. Development of local inbred lines for the production of sunflower hybrids having desirable traits such as early maturity, short stature, semi-erect heads, high oil content, drought and disease resistant.	1	1.0	100000	1.0	140000	1.0	160000	1.0	185000	1.0	185000	1.0	270000
3. Improve the existing varieties of rapeseed-mustard and develop new ones having '00' character for crucic acid and glucosinolates.	1	1.0	30000	1.0	51570	1.0	57120	1.0	66510	1.0	66120	1.0	95970
4. Develop short duration, high yielding groundnut with resistance to common pests and diseases.	1	1.0	65000	1.0	95000	1.0	105000	1.0	125000	1.0	120000	1.0	180000
5. Generating segregating material for the development of soybean varieties of early maturity and high yield.	1	0.5	60000	0.5	80000	0.5	95000	0.5	110000	0.5	105000	0.5	150000
6. Breeding for charcoal rot resistance in sunflower.	1	0.5	55000	0.5	80000	0.5	90000	0.5	100000	0.5	110000	0.5	120000
7. Determining economic threshhold of major insect pests of sunflower and evaluation of different control measures including pesticides, biological control and microbial agents with the collaboration of entomology research laboratory.	1	1.0	29000	1.0	42000	1.0	50000	1.0	58000	1.0	58000	1.0	85000
8. Develop machinery for planting, threshing and harvesting for oilseed crops. This will be done through farm machinery institute, MARC.	1	-	-	-	-	-	-	-	-	-	-	-	-

continued

OILSEEDS: Resource Requirements (continued)

Project Title	Priority	1988 / 89 Staff*	1988 / 89 Op.F**	1989 / 90 Staff	1989 / 90 Op.F	1990 / 91 Staff	1990 / 91 Op.F	1991 / 92 Staff	1991 / 92 Op.F	1992/93-1995/96 Annual average Staff	1992/93-1995/96 Annual average Op.F	1996/97-1999/00 Annual average Staff	1996/97-1999/00 Annual average Op.F
9. Breeding for collar rot resistance in sunflower.	2	-	-	-	-	-	-	0.5	30000	0.5	35000	0.5	50000
10. Breedinbg for aphid resistance in rapeseed-mustard	2	0.5	30000	0.5	43000	0.5	50000	0.5	58000	0.5	58000	0.5	85000
11. Breeding soybean varieties resistant to yellow mosaic virus, pod blight and purple seed stain.	2	1.0	60000	1.0	85000	1.0	100000	1.0	120000	1.0	140000	1.0	255000
12. Develop production technologies for sunflower, soybean, rapeseed-mustard and groundnut for barani areas near and around ICT.	2	0.5	50000	0.5	70000	0.5	80000	0.5	95000	1.0	95000	1.5	140000
13. Study economic returns by fitting sunflower and soybean crops in different crop rotations under various cropping systems.	2	-	-	-	-	0.5	40000	1.0	47000	1.0	50000	1.5	74000
14. Study major insects, predators and parasites' life tables to build crop growth and insect development models and develop forecast system for sunflower with the collaboration of entomology research lab.	2	-	-	-	-	0.5	30000	0.5	35000	1.0	35000	1.0	50000
15. Utilization of cake and meal of oilseed crops in humen diet and animal feed with the collaboration of animal nutrition lab.	2	-	-	-	-	-	-	1.0	40000	1.0	40000	1.0	80000
16. Enhancing sunflower inbred lines development process by using tissue culture techniques and other biotechnological methods with the collaboration of tissue culture lab.	3	-	-	-	-	-	-	-	-	0.5	30000	1.0	45000
17. Establishing electrophoresis techniques for identification of inbred lines and tracing gene markers with the collaboration of tissue culture.	3	-	-	-	-	-	-	-	-	0.5	40000	1.0	55000
Total		8.0	554000	8.0	786570	9.0	972120	11.0	1204510	13.0	1302120	15.0	1934970

BUDGET							
	Staff Costs: Existing (1988/89 + 3%/year)	1245524	1282993	1321482	1361127	2191169	3208091
	Additional	0	19533	86400	171361	158659	204151
	Operational Funds	554000	786574	972120	1204515	1302121	1934576
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	1799624	2089100	2380002	2737003	3651949	5346818

* Number of Scientists (BP 17-20) 5 SSO, 4 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SUGAR CROPS: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Acquisition, documentation and distribution of sugarcane germplasm for high yield, resistance to diseases and insect pests, tolerance to frost, drought and problem soils.	1	1.0	63000	0.5	65000	0.5	95000	1.0	100000	1.0	110000	1.0	188000
2. Acquisition, documentation and distribution of sugarcane germplasm for high yield, early maturity, resistance to insects and diseases.	1	-	-	0.5	32120	0.5	42098	1.0	63394	1.0	84334	1.0	100725
Total		1.0	63000	1.0	97120	1.0	137098	2.0	163394	2.0	194334	2.0	288725

BUDGET	Staff Costs: Existing (1988/89 + 3%/year)		205584		211752		218104		224647		327020		478790
	Additional		0		0		0		20442		23679		30468
	Operational Funds		63000		97120		137098		163394		194334		288725
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)		268584		308872		355202		408483		545033		797983

*Number of scientists (BP 17-20) 1 SSO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

VEGETABLE CROPS: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Development of cost efficient methods to produce off-season vegetables.	1	2.0	200000	2.0	200000	2.0	125000	2.0	100000	-	-	-	-
2. Screening of onions for better shelf life, uniformity, quality and higher yield.	1	1.0	18000	1.0	25000	1.0	26000	1.0	42000	1.0	50000	1.0	65000
3. Use of growth regulators to enhance the storage life of onions.	1	1.0	14000	1.0	25000	1.0	26000	1.0	38000	1.0	50000	1.0	65000
4. Identifying parents for F1-hybrid seed production in tomatoes.	1	1.0	14000	1.0	21575	1.0	25743	1.0	30342	1.0	35881	1.0	50000
5. Selection and breeding of chillies for resistance. against Phytopthora species.	2	1.0	12000	1.0	20000	1.0	24000	1.0	30000	1.0	35000	-	-
6. Selection and breeding of tomatoes for shelf life, uniformity, quality and higher yield.	2	1.0	12000	1.0	24000	1.0	29000	1.0	34000	1.0	35000	-	-
7. Development of seedless water melons.	2	-	-	1.0	10000	1.0	15000	1.0	20000	1.0	25000	1.0	35000
8. Selection of peas for drought tolerance under barani conditions.	2	-	-	1.0	20000	1.0	26000	1.0	32000	1.0	35000	1.0	55000
9. Selection of peas for powdery mildew resistance.	2	-	-	1.0	20000	1.0	26000	1.0	32000	1.0	35000	1.0	55000
10. Popularizing techniques for spawn production and cultivation of edible mushroom.	2	-	-	1.0	15000	1.0	18000	1.0	25000	1.0	33000	1.0	50000
11. Research in seed production of crucifiers.	2	-	-	-	-	2.0	40000	2.0	50000	2.0	50000	2.0	64993
12. Development of mechanized sowing, transplanting and harvesting devices for vegetables.	2	-	-	-	-	1.0	45000	1.0	60000	1.0	80000	1.0	150000
13. Select tomatoes for biotic stress(heat) tolerance.	2	-	-	-	-	1.0	26000	1.0	32000	1.0	34000	1.0	60000
14. Selection of tomatoes for high salt tolerance.	2	-	-	-	-	-	-	1.0	24000	1.0	50000	1.0	90000
15. Introduction of new vegetables.	2	-	-	-	-	-	-	1.0	15000	1.0	30000	1.0	70000
16. Development of suitable control measures of major insects pests of this region in vegetable crops.	3	-	-	-	-	-	-	1.0	15000	1.0	20000	1.0	55000
17. Eco.studies of major insect pests of veg. at NARC	3	-	-	-	-	-	-	-	-	1.0	20000	1.0	53000
Total		7.0	270000	11.0	380575	15.0	451743	18.0	579342	17.0	617881	15.0	917993

BUDGET							
	Staff Costs: Existing (1988/89 + 3%/year)	583956	601475	619519	638104	1039752	1522301
	Additional	0	0	58095	81314	75287	96874
	Operational Funds	270000	380575	451743	579342	617881	917993
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	853956	982049	1129357	1298760	1732920	2537168

* Number of scientists (BP 17-20) 1 PSO, 2 SSO, 5 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

FRUIT CROPS: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Introduction and evaluation of germplasm of loquat guava, strawberry, citrus and deciduous fruits with low chilling requirements.	1	2.0	25000	1.0	35000	1.0	60000	1.0	100000	1.0	109000	1.0	149000
2. Studies on the asexual propagation of guava and loquat.	1	1.0	10000	1.0	15000	-	-	-	-	-	-	-	-
3. Ploidy manipulation for crop improvement in guava and loquat.	1	1.0	15000	1.0	20000	1.0	40000	1.0	40000	1.0	49000	-	-
4. Histological studies on shoot tips to find out the initiation of of bud dormancy in peach.	1	2.0	20000	1.0	30000	-	-	-	-	-	-	-	-
5. Studies on rootstock and scion interaction in swee orange, mandarin, peaches etc.	2	1.0	10000	2.0	35000	2.0	60000	2.0	100000	2.0	129000	1.0	100000
6. Nutritional studies in peaches, citrus fruits and strawberry.	2	1.0	15000	1.0	20000	1.0	40000	1.0	60000	1.0	69000	1.0	100000
7. Standardization of prod. tech. for non-traditional fruit crops like strawberry, kiwi fruit, fig etc.	2	1.0	15000	1.0	20000	1.0	50000	1.0	70000	1.0	90000	1.0	130000
8. Studies on the post-harvest physiology of peach, citrus, guava and strawberry.	3	-	-	1.0	50199	2.0	70000	1.0	90000	1.0	100000	2.0	150000
9. Physiological studies for different growth process in peach, grapes, citrus, guava and loquat.	3	-	-	-	-	1.0	40639	1.0	40000	1.0	60000	1.0	100000
10. Breeding & cytogenetic studies in citrus and peach	3	-	-	-	-	-	-	1.0	19445	1.0	40000	1.0	70000
11. Studies on the micropropagation of cornation and chrysanthemum.	3	-	-	-	-	-	-	-	-	1.0	41024	1.0	64000
12. Studies on the establishment of high density orchards through various techniques in peach and mandarine.	4	-	-	-	-	-	-	-	-	-	-	2.0	139419
Total		9.0	110000	9.0	225199	9.0	360639	9.0	519445	10.0	687024	11.0	1002419

BUDGET													
	Staff Costs: Existing (1988/89 + 3%/year)		822492		847167		872582		898759		1135375		1662302
	Additional		0		0		0		0		69893		105783
	Operational Funds		110000		225199		360639		519445		687024		1002419
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)		932492		1072366		1233221		1418204		1892292		2770504

* Number of Scientists (BP 17-20) 1 SSO, 8 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SEED SCIENCE AND TECHNOLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Determination of seed quality attributes and their relation with field performance.	1	1.0	51891	1.0	59675	1.0	78247	1.0	98893	1.0	93865	1.0	139457
2. Seed invigoration/stress alleviation in various crop through seed coating, seed pelleting etc.	1	1.0	51891	1.0	59675	1.0	78247	1.0	98893	1.0	93865	1.0	139457
3. Determination of factors contributing the weed seed banks in agricultural soils.	1	1.0	51891	1.0	59675	1.0	78247	1.0	98893	1.0	93865	1.0	139457
4. Maintenance and exchange of healthy seed.	1	1.0	51891	1.0	59675	1.0	78247	1.0	98893	1.0	93865	1.0	139457
5. Electropheratic separation of isozymes for accession identification and as genetic marker.	1	1.0	51891	1.0	59675	1.0	78247	1.0	98893	1.0	93865	1.0	139457
6. Osmoconditioning of vegetable seeds to improve emergence and yield.	2	1.0	51891	1.0	59675	1.0	78247	1.0	98893	1.0	93865	1.0	139457
7. Seed polymorphism, effect of photo period and thermo period on germinability and vigorosity of seed.	2	1.0	51891	1.0	59675	1.0	78247	1.0	98893	1.0	93865	1.0	139457
8. Biological control of seed borne diseases.	2	1.0	51891	1.0	59675	1.0	78247	1.0	98893	1.0	93865	1.0	139457
9. Effect of temperature and moisture on seed longevity.	2	1.0	51896	1.0	59678	1.0	78249	1.0	98899	1.0	93869	1.0	139459
Total		9.0	467024	9.0	537078	9.0	704225	9.0	890043	9.0	844789	9.0	1255115

BUDGET													
	Staff Costs: Existing (1988/89 + 3%/year)		700536		721552		743199		765495		1421587		2081345
	Additional		0		84064		96674		111175		102935		132449
	Operational Funds		467024		537078		704225		899043		844789		1255115
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)		1167560		1342694		1544098		1775713		2369311		3468909

* Number of scientists (BP 17-20) 1 PSO, 4 SSO, 4 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

PLANT GENETIC RESOURCES: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Conservation and maintenance of crop germplasm.	1	1.0	15000	0.5	30000	1.0	45000	1.0	70000	1.0	100000	1.0	150000
2. Exploration and collection of crop germplasm.	1	1.0	5000	0.5	15000	0.5	18000	1.0	36103	1.0	50000	1.0	70000
3. Preliminary evaluation and multiplication.	1	0.5	5000	0.4	10000	0.5	15000	0.5	25000	1.0	50000	1.0	70000
4. Exchange and supply of germplasm.	1	0.5	5000	0.3	5000	0.4	13112	0.5	20000	1.0	30000	1.0	50000
5. Documentation on crop genetic resources informatio	1	-	-	0.3	5000	0.3	10000	0.5	20000	1.0	30399	1.0	48051
6. Detail evaluation of crop germplasm.	2	-	-	0.3	5000	0.4	15000	0.5	20000	1.0	30000	1.0	45000
7. Cryopreservation, variation studies and conservation of vegetatively propagated material.	2	-	-	0.3	9288	0.4	18000	0.5	25000	1.0	35000	1.0	40000
8. Collection and conservation of vegetatively propagated plants (Clonal Repository).	2	-	-	0.4	10000	0.5	25000	0.5	25000	1.0	40000	1.0	50000
Total		3	30000	3	89288	4	159112	5	241103	8	365399	8	523051

BUDGET	Staff Costs: Existing (1988/89 + 3%/year)	456564	470261	484369	498900	593242	867371
	Additional	0	0	0	0	28736	55196
	Operational Funds	30000	89288	159112	241103	365399	523051
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	486564	559549	643481	740003	987377	1445618

* Number of scientists (BP 17-20) 1 PSO, 1 SSO, 1 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

PLANT INTRODUCTION CENTRE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Introduction of plants suitable for problematic soils/stress conditions.	1	0.4	12600	0.4	21065	0.4	30996	0.4	40990	0.4	45000	0.5	65000
2. Introduction of plants bearing edible/industrial oil.	1	0.3	6930	0.3	11586	0.3	17048	0.3	22548	0.3	25000	0.3	35000
3. Aquisition of germplasm and post entry quarantine.	1	0.3	11970	0.3	20011	0.3	29447	0.3	38947	0.3	45000	0.5	55000
4. Documentation and exchange of germplasm.	1	0.25	8820	0.25	14745	0.25	21697	0.25	34700	0.25	50799	0.5	65000
5. Introduction of food and feed legumes which are disease resistant and also provide the fodder during lean periods.	2	0.25	10080	0.25	16852	0.25	24797	0.25	31797	0.25	35000	0.5	65000
6. Introduction of new fruits and vegetables.	2	0.25	7560	0.25	12639	0.25	18598	0.25	20000	0.25	25000	0.4	45000
7. Introduction of medicinal plants and spices.	2	0.25	5040	0.25	8426	0.25	12399	0.25	16000	0.25	18000	0.3	32215
Total		2.0	63000	2.0	105324	2.0	154982	2.0	204982	2.0	243799	3.0	362215

BUDGET													
	Staff Costs: Existing (1988/89 + 3%/year)	273948	282166	290631	299350	410258	600659
	Additional	0	0	0	8123	29706	38224
	Operational Funds	63000	105324	154982	204982	243799	362215
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	336948	387490	445614	512456	683763	1001098

* Number of scientists (BP 17-20) 2 SSO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

TISSUE CULTURE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Pre basic seed production through micropropagation and new approaches like in vitro tuberization and somoclonal variation.	1	1.0	20000	1.0	30000	1.0	45000	1.0	55000	0.5	40000	-	-
2. Somoclonal variation in wheat/rice through embryo and other culture.	1	2.0	30000	2.0	60000	2.0	120000	2.0	170000	2.0	200000	2.0	240000
3. Micro propagation in date palm.	1	1.0	20000	1.0	50000	1.0	70000	1.0	100000	1.0	100000	1.0	100000
4. Virus elimination/disease resistance in selected horticulture and vegetable crops.	1	1.0	5000	1.0	12000	1.0	20000	1.0	40000	1.0	50000	1.0	100000
5 Identification of cellular proteins and messengers involved in embrogenesis and stress tolerance.	1	1.0	15000	1.0	42000	1.0	68618	1.0	95000	1.0	100000	1.0	120000
6. Cell culture/protoplast cultures.	1	1.0	10000	1.0	27132	1.0	40000	1.0	70757	1.5	80000	1.0	110000
7. Cell fusion.	2	-	-	-	-	-	-	-	-	0.5	40000	1.0	80000
8. Developments of physical transfer techniques/ vector for genetic manipulation.	2	-	-	-	-	-	-	-	-	1.0	80000	1.5	238259
9. Isozyme analysis to evaluate the marker system.	2	-	-	-	-	-	-	-	-	0.5	39833	0.5	70000
Total		7.0	100000	7.0	221132	7.0	363618	7.0	530757	9.0	729833	9.0	1058259

BUDGET								
Staff Costs: Existing (1988/89 + 3%/year)	884436	910959	938298	966447	1198620	1754900
Additional	0	0	0	0	69248	111675
Operational Funds	100000	221132	363618	530757	729833	1058259
Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	984436	1132101	1301917	1497204	1997701	2924834

* Number of scientists (BP 17-20) 1 PSO, 7 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

CYTOGENETICS: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Alien genetic transfer for rust resistance and tolerance in wheat.	1	2.0	7000	2.0	21000	2.0	40000	2.0	62000	2.0	97000	2.0	118600
2. Species introgression for improved economic characterization in brassica.	1	1.0	7000	1.0	26889	2.0	43370	2.0	65928	2.0	113768	2.0	121902
3. Interspecific hybridization for high yield and toxin free grass-pea.	2	1.0	5000	1.0	15000	1.0	29000	1.0	44000	1.0	61000	2.0	78600
4. Induction of sterility in tea for better vigour.	2	1.0	5000	1.0	15000	1.0	29000	1.0	44000	2.0	61000	1.0	78600
5. Developing seedless fruits through polyploidy for improved quality.	2	-	-	-	-	-	-	-	-	-	-	1.0	78600
Total		5.0	24000	5.0	77889	6.0	141370	6.0	215928	7.0	332768	8.0	476302

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	419076	431648	444598	457936	541153	789847
	Additional	0	0	0	0	25206	50263
	Operational Funds	24000	77889	141370	215928	332768	476302
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	443076	509537	585968	673863	899127	1316412

* Number of scientists (BP 17-20) 1 SSO, 4 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

FOOD TECHNOLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Screening of germplasm/advance lines/varieties of cereals legumes and oilseeds grown in different agro-ecological zones for nutritional quality and consumer acceptance.	1	3.0	50000	3.0	90000	3.0	200000	3.0	250000	3.0	350000	3.0	450000
2. To have more bread from less wheat by using traditional cereals for partial replacement of wheat.	1	2.0	30000	2.0	58905	-	-	-	-	-	-	-	-
3. Nutritive value of traditional chickpea products consumed in Pakistan.	1	2.0	20000	2.0	60000	-	-	-	-	-	-	-	-
4. Effect of storage of nutritional quality and consumer acceptance of legumes, fruits and vegetables.	1	1.0	12000	1.0	40000	2.0	70000	2.0	100000	-	-	-	-
5. Nutritional evaluation of diets consumed in different agro-ecological zones.	2	-	-	-	-	2.0	90000	1.0	120000	2.0	150000	-	-
6. Effect of production environment on the nutritional quality and antinutritional factors in legumes.	2	-	-	-	-	-	-	1.0	50000	2.0	80000	2.0	120000
7. Effect of processing (soaking, germination, cooking, baking, milling etc.) on the nutrient losses, technological value and nutritional quality of cereals and legumes.	2	-	-	-	-	1.0	49948	1.0	78859	1.0	120000	2.0	150000
8. Quality evaluation of new varieties of vegetables and fruits.	2	-	-	-	-	-	-	-	-	1.0	125346	1.0	150000
9. Determine the levels of nitrate, nitrite and nitrosamines in vegetables, meat and milk.	3	-	-	-	-	-	-	-	-	-	-	1.0	150000
10. Effect of national agricultural policies on the nutritional status of local population, using standard survey methodology (FAO).	3	-	-	-	-	-	-	-	-	-	-	1.0	176326
Total		8.0	112000	8.0	248905	8.0	409948	8.0	598859	9.0	825346	10.0	1196326

BUDGET							
Staff Costs: Existing (1988/89 + 3%/year)	1000872	1030898	1061825	1093680	1355000	1983856
Additional	0	0	0	0	77988	126245
Operational Funds	112000	248905	409948	598859	825346	1196326
Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	1112872	1279803	1471773	1692539	2258334	3306427

* Number of scientists (BP 17-20) 1 CSO, 1 PSO, 1 SSO, 5 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

PLANT PROTECTION

Crop Diseases Research Institute

It seems hardly necessary to say that plant diseases, are important because they reduce crop yields. Just by way of example, controlling all diseases of wheat would add 20% to the world's wheat supply. The major production problems are:

- In wheat, rusts, smuts, powdery mildew, root rots and leaf spots.
- In maize, stalk rot and foliar blights.
- In sunflower, charcoal rot.
- In sorghum and millets, smuts, mildews, grain molds and charcoal rot.
- In vegetables, blights and fruit rots.
- In pome and stone fruits, blights, scabs, foot and crown rots.
- In citrus fruits, foot and crown rots, mycoplasma, virus and virus-like diseases.
- Seed and fruit rots.

Goals and objectives. The Crop Diseases Research Institute restricts its activities to:

- Problem-oriented research in the area of phytopathology.
- Coordinating phytopathological research in the country.
- Helping the plant breeders of the country in developing disease-resistant varieties of crop plants.

Mandate. Minimizing disease losses at the farm level through evolution of high yielding, disease-resistant varieties suitable for various zones is the mandate of the Crop Diseases Research Institute.

Current programme. Plant pathological research in the institute is governed by the fundamental principle that research work which is being or could be undertaken by a provincial institute or a university will not be duplicated. For example, because the agricultural research institutes in the provinces work on chemical control of plant diseases, the institute does not undertake this work except for the specific purpose of helping the farmers in the Islamabad Capital Territory. The institute emphasizes research on host-parasite genetics involving major crops and their important parasites, epidemiology of major plant diseases, and physiology of disease development and resistance.

Proposed programme

Priority 1

- Host-parasite genetics involving major crops such as cereals, vegetables, fruits, and oilseeds and their important parasites.
- Epidemiology of major plant diseases.
- Identification of sources of resistance to rusts, Powdery mildew, footrots, and BYDV in wheat, barley, and triticales.
- Diversification of the genetic base for resistance to rusts in wheat.
- Epidemiology of wheat rusts in Pakistan to identify sources of inoculum and changes in virulence spectra of rust parasites.
- Identification of sources of resistance to mildew and wilt in peas and cucurbits; mildew, charcoal rots and leaf spot in oil crops; blights, wilts, viruses and nematodes in solanacious vegetables.
- Physiology and control of charcoal rot in sunflower.
- Epidemiology of foliar diseases in maize.
- Biology and control of stalk rots in maize.

- Sources of resistance against foliar diseases, smuts, and downy mildew in sorghum and millet.
- Sources of resistance against foliar diseases and smut in rice.
- Services to plant breeders such as disease monitoring, pathogenicity analyses, and supply of inocula.

Priority 2

- Seed pathology of cereals, vegetables, and fibre crops.
- Phyto-bacteriology.
- Pathology of crown and root rot in apple.
- Sources of resistance against red rot and whip smut in sugarcane.
- Control of root knot nematodes and powdery and downy mildews in vegetables.
- Identification of root stocks resistant to *Phytophthora* spp. in pone and stone fruits and to canker and viruses in citrus.
- The mycological herbarium will be maintained and up-dated.

Advanced research. Specialized investigations will include more in-depth studies on the physiology and biochemistry of plant disease development and resistance especially in major crops, use of molecular biology techniques in identifying phylogenetic associations between different pathogenicity groups of biotrophic, as well as necrotrophic disease causing agents, use of immunosorbent assays for identification of pathogenic variation in phytobacteria and use of molecular biology and biochemical procedures for identification of resistance to plant diseases.

Linkages and relationships. The institute has laid great emphasis upon collaboration in research with internationally recognized seats of learning overseas and training of post-graduate students in local universities for master's and doctoral degrees. On campus, the institute collaborates with programmes on wheat, maize, pulses, oilseeds, horticulture, and tissue culture. It also collaborates with all provincial research institutes and NWFP Agricultural University; University of Agriculture, Faisalabad; Barani Agricultural College; Sind Agricultural University; and Quaid-i-Azam University (for M.S. and doctoral research).

Currently the institute is collaborating at the international level with Plant Breeding Institute, University of Sydney; CIMMYT; ICARDA; and IPO. This collaboration will continue and will be extended to Cambridge University, U.K.; IVP Agriculture University, Netherlands; and Institute of Plant Protection, Iran.

Expected accomplishments

- The genetic basis of resistance in wheat to rusts, powdery mildew, and smuts will be diversified.
- Cultivars with durable resistance will be developed.
- Resistance from alien sources will be transferred into bread wheat.
- Any new virulences that might have developed among the parasites affecting wheat and other cereals will be identified.
- Resistances to diseases in oil crops will be identified through biotechnological techniques.
- Sources of inoculum of wheat rusts will be located.
- Root stocks resistant to crown and root rot of apple will be identified.

Plant Virology

Although virus and virus-like diseases were recorded in Pakistan some 60 years ago, no practical work was done until recently. This was due to difficulties in identification by simple means, lack of specialists in this field, lack of appropriate laboratory facilities, and underestimation of the losses caused by these diseases. As a result these diseases have spread,

inoculum potential has built up, populations of viruliferous vectors have grown, and crop varieties have degenerated, especially those vegetatively propagated. Virus diseases are now widespread in all field crops, vegetables, fruit trees, and ornamentals, and they cause heavy losses. With the establishment of a well-equipped plant virology laboratory at NARC, it has become possible to investigate, identify, and characterize viruses, determine vectors and mode of transmission, develop manpower in this field, assist in production of virus-free material, and work out suitable control measures.

The major production problems are:

- Degeneration of vegetatively propagated crops (e.g. potato, sugarcane etc.) and decline in the productive life span of fruit trees, due to infections of virus and virus-like diseases.
- Marked increase in the population of viruliferous insect vectors (e.g. aphids, whitefly and hoppers) and weed hosts for plant viruses.
- Mixed viral infections in crop plants resulting from contact, seedborne, and insect transmission, affecting resistance and assessment of losses.
- Introduction of new viruses and strains due to indiscriminate introduction of germplasm and ineffective quarantine.
- Ineffective and inefficient nitrogen fixation or nodulation in legume hosts due to virus diseases.

Goals and objectives. The principal aims of the plant virology programme are:

- To identify and characterize important viruses (particularly affecting field crops; vegetables, legumes, sugarcane, and citrus) on the basis of their biological, serological, and physico-chemical properties.
- To study epidemiology of important viruses and virus-vector relationships.
- To purify important viruses, antisera production, and prepare ELISA kits to be used in the production of virus-free material.
- To study viroids and mycoplasmic diseases of selected hosts.
- To develop control measures through varietal screening, cross protection, thermotherapy, vector control, and protected nurseries.

Mandate. The NARC plant virology unit is to develop the discipline and conduct fundamental and applied research on important virus and virus-like diseases of crop plants. Research topics include proper identification and characterization of viruses, virus-vector relationships, and development of proper control measures so that the losses caused by these diseases are averted.

Current programme. Present activities include surveys and collection of viruses and compilation of data on their distribution in Pakistan, estimation of economic losses, identification and characterization of important viruses, investigation of the mode of transmission and vectors; purification of viruses and production of antisera. Important viruses of potato, tomato, tobacco, sugarcane, mungbean, citrus, and papaya are studied. In combating virus diseases, the group screens genetic material for resistance to viruses and participates in commodity programmes, assists in the production of virus-free material, and develops other control measures for selected viruses.

Proposed programme

Priority 1

- Identification and characterization of specific virus diseases infecting cereals, sugarcane, vegetables, citrus, and papaya.
- Ecology and epidemiology of important virus including assessment of losses.

- Purification of important viruses for the purpose of antisera production and for ELISA kits (potato, tomato, sugarcane, and citrus).
- Screening of varieties of barley, sugarcane, potato, and tomato for resistance against viruses.
- Investigation of legume viruses (chickpea, mungbean, soybean, and peanuts) with respect to their identity, mode of transmission, and methods of control.
- Development of proper control measures of virus diseases.

Priority 2

- Virus-vector relationships and vector population dynamics of aphids and whitefly.
- Control of insect vectors of potato and chickpea through nuclear polyhedrosis viruses.
- Assistance in the development of production of virus-free material of potato, tomato, sugarcane, and citrus.

Priority 3

- Viroids and mycoplasma diseases of potato, sugarcane, citrus, and sesame.

Advanced research. Advanced research includes purification of viruses, antisera production, monoclonal antibodies, ELISA tests, electron microscopy, RNA-RNA hybridization, genetic engineering, cDNA probes, and viruses as vectors for plant genes.

Linkages and relationships. On campus, plant virology will require participation with commodity programmes in maize, sugarcane, legumes, and fruits and vegetables and with the disciplines of entomology (vector and transmission studies), pest management, weed science, and tissue culture (production of virus-free material). The programme will have linkages with all the provincial institutes for specific problems, exchange of material, and site-specific experiments, so that the discipline is strengthened. The programme will fully cooperate with the Federal Seed Certification Department and plant quarantine. Linkage with international centres will include exchange of material, provision of seeds of indicator and propagative hosts of viruses, supply of viral antisera, and data exchange.

Expected accomplishments

- A large number of virus diseases infecting cereals, solanaceous crops, sugarcane, citrus, and papaya will be identified on the basis of their biological, serological, and physico-chemical properties.
- The ecological distribution of virus diseases and their taxonomic position in Pakistan will become clear. The collection may include several new viruses from Pakistan. Losses due to important viruses of potato, legumes, tomato, sugarcane, and citrus, etc. will determine research priorities in future.
- Development of methods of purification of important viruses will lead to antisera production and preparation of ELISA kits, reducing the need for imports of the kits.
- All vectors of plant viruses will become known and their population dynamics will be revealed.
- Emphasis given to legume viruses will lead to their identification, greater understanding of their transmission by seed, and development of control measures, giving yield increases of more than 25%.
- Identification of sources of resistance, particularly of tomato against tomato mosaic and leaf curl viruses, potato against degeneration viruses, and sugarcane against sugarcane mosaic virus will help the breeders.
- Production of virus-free material will be of great value for yield increases and reduced imports of seed potato.

- Scientific material such as seeds of indicator hosts, antisera, type cultures, and ELISA kits will be exchanged with the foreign scientists.

Entomology

In order to achieve the maximum potential of field crops, pest control measures, especially integrated pest management (IPM), play a vital role. IPM depends on the development of a sound forecasting system, exploration of economic and ecologically safe and acceptable protection systems, and their integration in a logical manner. Research goals in entomology, although diverse, have been oriented towards that approach.

The major production problems are:

- Susceptibility of new and exotic field crop lines to insect pest attack.
- Inadequate integrated pest management packages.
- Lack of an early pest warning system, or an efficient crop protection service.
- Post-harvest losses during storage of grain.
- Ignorance of environmental considerationS and misuse of pesticides due to overcompetition and inadequate knowledge amongst farmers.

Goals and objectives. The principal aims of the entomology programme are:

- To protect the major field crops, food grains, fruits, vegetables, and livestock from insect pests through suitable and easily adaptable technology.
- To develop a forecasting system and make the system preventive rather than curative.
- To develop an environmentally safe and acceptable plant protection system.

Mandate. Entomology research aims to develop methods for tackling insect pest problems at their roots, i.e. to develop preventive rather than curative plant protection systems, with the help of modern scientific tools. The ultimate goal is to allow the farmer to realize maximal potential from his crop, minimize post-harvest losses, and achieve insect- and disease-free livestock production.

Current programme. The entomology programme at NARC received its mandate only a year ago. The main activities are screening of rice and wheat varieties for resistance to insect pests, developing a pest scouting and forecasting system for sugarcane and rice, along with integrated pest management programmes for these crops. Storage losses in cereal grains at the farm level, in villages, and public stores are under way. Sampling methods, biology, ecology, and appropriate controls for "barani" fruits and vegetables are also a part of current research. Protection of the environment from insecticidal pollution through eco-toxicological studies are carried out including development of bio-rational pesticides, monitoring resistance, residue analysis, and isolation and identification of sex pheromones.

Proposed programme

Priority 1

- Estimation of losses caused by major insect pests at various densities, and establishment of cultures of important natural enemies of major pests.
- Development of pest scouting and integrated pest management technology for insect pests of rice, sugarcane, maize, sorghum, oilseed crops, pulses, and fruit and vegetables.
- Study of the ecology of storage losses due to insect pests in important food grains in central and northern Pakistan and development of effective fumigation techniques.
- Survey of the insect pests of livestock and poultry, estimation of losses caused by them, and development of effective control measures.

Priority 2

- Screening of rice, sugarcane, maize, sorghum, pulses, oilseeds, and cereal germplasm for resistance against insect pests.
- Identification of strains and biotypes of major crop and stored pests resistant to insecticides and development of packages of technology for the management of insecticide resistance.
- Evaluation of fourth generation pesticides (viruses, bacteria, protozoa, nematodes, botanical pesticides).

Priority 3

- Determination of side effects of pesticides on non-target organisms and their role in environmental pollution and development of safe pesticide application techniques.
- Development of computer models for forecasting population densities of insect pests in different ecological zones.

Priority 4

- Isolation, identification, and integration of sex pheromones in IPM models.
- Identification of insect vectors of viral diseases, and development of techniques for their control.

Advanced research. Advanced research will involve studies of host-plant interaction, computer modelling, plant protection at the molecular level, biochemistry, X-ray photography of damaged stored grains. Future plans includes electron microscopy, radio-tracer techniques, behavioural studies using time-lapse photography, and chromatography.

Linkages and relationships. On campus, entomology cooperates with the wheat programme to determine the feasibility of adopting no-tillage cultivation in wheat. Also breeders' material and cultivars of rice and wheat are screened for resistance against field and stored grain pests. The information is passed on to the breeders. In cooperation with plant virology, studies on the virus-vector relationship of aphids are undertaken and in cooperation with the Animal Sciences Institute, insect pests of livestock are being investigated. Provincial centres with which entomology cooperates are Rice Research Institute, Kala Shah Kaku; Rice Research Institute, Dokri, Sind; University of Agriculture, Peshawar; Pest Warning and Pesticide Quality Control department, Multan; University of Karachi; Gomal University, D. I. Khan; and Agricultural Research Institute, Quetta. The entomology programme also collaborates with Al-Noor Sugar Mill, Moro, Sind.

International linkages are maintained with International Rice Research Institute; CIMMYT; Oklahoma State University; Plant Sciences Research Facility, USDA, ARS, Oklahoma, USA; Federal Environmental Assessment Review Officer, Canada; University of Glasgow; Shell Research Limited, UK; and Johannes Gutenberg University.

Expected accomplishments

- Integrated pest management technology for major insects of crops like rice, sugarcane, wheat, maize, pulses, fruits and vegetables will be available for implementation in farmers' fields.
- Suitable control techniques for stored grain insect pests will be available for use by farmers and provincial food department staff.
- Facilities for routine testing of the resistance of new germplasm to insect pests will be available for varietal screening in any breeding programme.
- Detailed knowledge of the state of resistance in insect pests to pesticides and ways to manage resistance will be available for efficacious use of insecticides. This, coupled with the safe and new pesticide application techniques, will minimize environmental risks due to the use of insecticides.

- Insect parasites, predators, pathogens, pheromones, and botanical pesticides will be the significant part of the prevalent integrated pest management schemes.
- On-line computer models for pest forecasting and pest management decision making will be available for plant protection staff.
- Research in livestock entomology (identification of serious pests, economic losses, and their control) is anticipated to contribute to the improvement of livestock production.
- Technology developed for the control of insect vectors will help in controlling viral diseases.

Weed Sciences

In Pakistan, weeds are one of the most important constraints to agricultural production. All ten of the worst and most noxious weeds of the world can be found in the crop fields and orchards of Pakistan. Losses suffered due to weeds run into billions of rupees per year. Weeds also cause serious problem in non-cropped areas such as lawns, factories, defense installations, airports, waterways, and even railways and roads. Nonetheless, little attention has been paid to the development of weed science research in Pakistan. At present there are few scientists actively involved. No institution except NARC has a group working solely on weed science.

The basic strategy of research is to concentrate on steps leading to an acceptable and safe weed management technology. These steps include the studies of biology, ecology, habitat distribution, and other issues which may provide basic information about weeds before a control strategy is developed. From information received through this basic research, control measures involving preventive, chemical, cultural, ecological, biological, and mechanical methods will be developed. Wherever possible an integrated approach based on these methods will be stressed.

The major production problems are:

- Reduced crop yields due to weed competition, parasitism, and allelopathy.
- Improper agronomic practices leading to intensification of weeds.
- Low herbicide efficiency: uneconomic doses, low spectrum of activity, low selectivity, low persistence.
- Complex herbicide application technology.
- Toxicological effects of herbicides on the environment.
- Different weed flora composition, and environmental factors requiring modified weed management technology in different ecologies.

Goals and objectives. The principal aims of the weed sciences programme are:

- Problem-oriented basic and applied research to study biology, ecology, habitat distribution, potential, and methods of dissemination and population dynamics of weeds of economic importance.
- Development of socio-economically acceptable and environmentally safe weed management technology.
- Coordination of weed science research efforts at the national level, and dissemination of information related to weeds.

Mandate. The mandate of the weed science program is to conduct basic and applied research on all crops of economic importance in collaboration with the commodity programs of NARC and provincial institutes to arrive at a socio-economically acceptable and environmentally safe weed management technology.

Current programme. Work is in progress on integrated weed management, which aims to combine chemical control methods with mechanical and cultural management techniques. New

herbicides are being screened and methods of application which are easier and more efficient are being studied. Cultural management methods include intercropping, planting procedures, water and fertilizer management, and mulching. Work is also in progress on interaction of weeds with light, temperature, and moisture as they affect germination, seedling growth, and reproduction of weeds.

Proposed programme

Priority 1

- Integrated weed management.
- Chemical weed control (doses, application times and methods, improving efficiency through tank mix, surfactants etc.)
- Developing ecological or cultural weed control methods such as cultural practices; water, fertilizer, and light management; seeding time; seeding methods; mulching.
- Identifying biological weed control agents—pathogens, insects, herbivores—for weeds of economic importance.
- Allelopathy.
- Identifying seedicides, dormancy breakers, germinators and their possible use in weed management.
- Biology of weeds of economic importance.

Priority 2

- Responses of weeds of economic importance to ecological factors.
- Weed distribution in different ecological zones of Pakistan and weed dynamics under different cultural practices and farming systems.
- Determining critical period of competition.

Priority 3

- Herbicide persistence in the soil and plant toxicology.
- Developing weed-forecasting mathematical expressions.

Linkages and relationships. On campus, weed science collaborates with commodity programs, entomology, pathology/virology, farming systems research, Biological nitrogen fixation, socio-economic unit, and Farm Machinery Institute. Weed science also collaborates with coordinating units at: ARI, Tarnab, Peshawar; ARI, Tandojam, Sind; AARI, Faisalabad; ARI, Sariab, Quetta; as well as with University of Agriculture, Faisalabad; University of Agriculture, Tandojam; University of Agriculture, Peshawar; and Nuclear Institute of Agriculture and Biology.

The international centres cooperating with weed science programme are the International Plant Protection Center, USA; International Rice Research Institute; Long Ashton Research Station, U.K; and South East Asian Weed Information Centre, Indonesia.

Expected accomplishments

- Improved weed management technology will be developed based on the existing resources and problems for major field crops.
- The efficacy of herbicides will be maximized through improvements in time, rate, and methods of application and use of surfactants, adjuvants, and tank mixing.
- New herbicides will be screened in the local environment against local weeds.
- Cultural practices such as tillage methods and levels, seeding time, rate and methods of fertilizer application, irrigation, light management, and mulching will be developed to minimize the weed problem.
- Biological agents which can parasitise weeds of economic importance such as *Convalvulus arvensis*, *Cyperus rotundus*, Typha, and Echhornia will be identified.

- Potential allelopathic plants will be identified.
- Seedicides and dormancy breakers will be identified as an aid in seedbed preparation.
- Weak links in the life cycles of the following weeds will be determined: *C. oxyacantha*, *C. rotundus*, *T. portulacastrum*, *S. halepense*, *C. arvensis*, *S. marianum*, *G. aparine*, *Circium arvensis*, *Lolium* sp., *Imperata* sp.
- Weed distribution in different zones of Pakistan will be mapped.
- Residues and persistence of the most commonly used herbicides will be assessed.
- Mathematical expressions for forecasting weed problems, particularly *C. oxyacantha*, will be developed.
- Improved technology will be disseminated to end users through training, workshops, mass media, and publications.

Vertebrate Pest Management

Vertebrate pests are a recurring problem for farmers in production of cereal grains, sugarcane, oilseeds, vegetables and fruits. Pre- and post-harvest losses due to vertebrate pests amount to several billion rupees per year. The major production problems are:

- Rats and mice cause pre-harvest crop losses in wheat, rice, and sugarcane.
- Wild boars damage maize and sugarcane production.
- Rats and mice cause post-harvest grain losses averaging about 30 kilograms per farm family per year.
- Porcupines are a major pest in agro-forestry programmes.
- Parakeets and other pest birds cause losses of oilseed crops (sunflower), grain, and citrus, mango, and guava.
- Farmers lack good methods for reducing these losses.

Goals and objectives. The principal aims of the vertebrate pest management programme are:

- To protect the major economic crops and stored food grains from vertebrate pests through simple, safe, inexpensive, and socio-economically acceptable technologies.
- To develop an environmentally safe and acceptable plant protection system.
- To extend developed technology through outreach and extension activities.

Mandate. Vertebrate pest management is to develop technologies, or adapt existing ones, to reduce crop losses caused by vertebrate pests at farm level and to protect stored grain.

Current programme. The vertebrate pest management project at NARC is still to be institutionalized. It began in 1985 with funds from USAID. The Denver Wildlife Research Center supplies technical back-up. The VPC project has surveyed pest-caused food losses in both public (provincial and PASSCO) grain storage facilities and in the private sector (wholesale grain markets and farmhouses). The most serious losses occur in farm and village storage. However, losses of crops before harvest are much more significant than post-harvest losses and the project has also worked equally on farmers' problems with vertebrate pests in food crops.

The main activities are identification and quantification of vertebrate pest problems in grain storage and in pre-harvest crops; development of new strategies and technologies to deal with rodents, wild boar, and several species of pest birds; development of training and extension materials for agricultural extension workers, grain storage personnel, and farmers.

Proposed programme

Priority I

- Studies on the biology and behaviour of wild boar, leading to development of

toxicants, baits, and bait delivery systems for control methods.

- Demonstrate existing technologies on the control of rodents in wheat and rice through operational research in different agro-ecological zones.
- To develop vertebrate pest control technologies for onward transmission to FSR/farmers, CMP programme, BARD etc.
- Studies of the stability of several rodenticides under local environmental conditions.

Priority 2

- Laboratory and field evaluation of various toxicants, repellents, bait materials, and formulations against major vertebrate pests.
- Development and evaluation of pre-harvest damage assessment methods.
- To study the fluctuation of rat population with rotation of crops and seasons in different agro-ecosystems.

Priority 3

- To study the biology of parakeet and other major bird pest species affecting cereal crops, oilseed crops, fruit orchards and to evaluate effective control techniques.
- To study porcupine biology, ecology in croplands and forestry areas and to evaluate various toxicants and fumigants for control.

Priority 4

- To assess the economic losses and develop control methods on pika, Murree vole, and other vertebrate pests in fruit orchards of mountainous valleys of Punjab, NWFP, and Baluchistan.
- To study the cost/benefit ratio of various control techniques of vertebrate pests in different crops.
- Development of technology transfer and outreach materials for use by agriculture extension workers.
- Development of technology and transfer of extension and outreach materials for grain storage management.

Advanced research. Advanced research will involve studies of aging methods [illegible] boar and porcupine; histological studies of animal tissues for reproductive and hormonal c[illegible]s; of animal, plant and soil samples for pesticide residues using chromatography and UV spectrophotometry; animal movements will be studied using radio-telemetry.

Linkages and relationships. On campus, the vertebrate pest management project cooperates with the entomology, oilseeds, maize, and wheat programmes. Close cooperation exists with the BARD programme regarding pest damage to groundnut, rapeseed and chickpea. The project cooperates with the farming systems research programme and with the training of rural women under FSR. Field work is carried out near Fatehjang to help reduce crop damage by wild boar and rodents. The project works closely with the crop maximization programme in a control demonstration area at Kunjah, Gujrat District, in providing an adaptable technology to farmers to protect wheat and rice from rodent damage. The project cooperates in devising work plans, surveys, and training with the Pest Management Research Institute, Karachi, and with the technology and transfer unit at NARC, in providing training to farmers in the Capital District. The project assists the Training Institute, NARC, in a once-a-year 2- to 3-week training course in Vertebrate Pest Management. Cooperative rese[illegible] studies are carried out with several principal investigators at the University of Agriculture, Fai[illegible]labad, on pests of irrigated crop lands.

Close linkages exist between the project and the Economic Analysis Network, Agricultural Data Collection and the Kansas State Food and Feed Grain Institute projects under Food Security Management.

International linkages are maintained with the FAO, Rome, and other FAO offices; with WHO, Geneva; with Colorado State University, Kansas State University, Food and Feed Grain Institute, and with the Denver Wildlife Research Center, Denver, Colorado. The Vertebrate Pest Section, Bangladesh Agricultural Research Institute, Joydebpur, Bangladesh, works in close cooperation with the VPC project ar NARC.

Expected accomplishments

- Transfer of existing technology to farmers through demonstrations on the control of rodent damage to wheat and rice.
- Complete research studies on the basic biology and behaviour of wild boar, porcupine, and rose-ringed parakeet.
- Development of efficient, inexpensive control methods for wild boar, porcupine in forestry, rose-ringed parakeet in sunflower, and pika and voles in apple orchards.
- Transfer of control technology and strategies to farmers through extension and training materials, pilot field trials, and large-scale control demonstrations.
- Pre-harvest damage assessment methods will be available for accurate collection of crop loss data and for precise evaluation of control methods.
- The stability, environmental hazards, and efficacy of several vertebrate pest toxicants under Pakistan conditions will be understood and recommendations on their safe use will be made.
- Control strategies based upon the seasonal fluctuations and movements of vertebrate pests in croplands will be developed and implemented.
- Development of a multimedia training package on vertebrate pest control for use by agricultural extension workers, grain storage personnel, and farmers, and dissemination of informational, extension, and training materials.

RESOURCE REQUIREMENTS: PLANT PROTECTION

CROP DISEASES RESEARCH INSTITUTE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Host:parasite genetics of major crops and their important parasites	1	3.0	100000	3.0	165000	3.0	225000	3.0	270000	3.0	350000	4.0	600000
2. Identification of sources of resistance to major diseases in wheat,barley and triticale.	1	3.0	100000	3.0	165000	3.0	225000	3.0	270000	3.0	350000	3.0	600000
3. Diversification of genetic base of resistance to rusts in wheat.	1	0.5	25000	0.5	40000	0.5	60000	0.5	80000	0.5	100000	0.5	150000
4. Epidemiology of wheat rusts.	1	0.5	30000	0.5	50000	1.5	80000	1.5	90000	1.5	120000	1.5	150000
5. Pathology and physiology of charcoal rot in sunflower	1	2.0	35000	2.0	55000	2.0	75000	2.0	85000	2.0	120000	2.0	150000
6. Biology and control of stalk rot in maize.	1	0.5	20000	0.5	35000	0.5	60000	0.5	75000	0.5	90000	0.5	120000
7. Sources of resistance against foliar diseases and smuts in rice	1	1.0	30000	1.0	45000	1.0	65000	1.0	85000	1.5	100000	1.5	125000
8. Ecology of foliar diseases of maize.	1	0.5	20000	0.5	40000	0.5	60000	0.5	80000	0.5	100000	0.5	125000
9. Sources of resistance to foliar diseases,smuts and downy mildews in sorghum and millet.	1	0.5	20000	0.5	40000	0.5	60000	0.5	80000	1.5	100000	1.5	115000
10. Identification of sources of resistance to major diseases in vegetables.	1	2.5	75000	2.5	100000	2.0	150000	2.0	180000	2.0	260000	3.0	400000

continued

CROP DISEASES RESEARCH INSTITUTE (continued)

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
11. Disease monitoring, inoculum production, virulence analysis and service to plant breeders.	1	4.0	75000	4.0	100000	4.0	150000	4.0	180000	4.0	260000	4.0	400000
12. Seed pathology of cereal, vegetable and oil crops.	2	1.5	20000	1.5	40000	1.5	60000	1.5	80000	1.5	100000	2.5	115000
13. Phytobacteriology.	2	2.0	30000	1.5	50000	1.5	65000	1.5	80000	1.5	100000	1.5	115000
14. Phytonematology.	2	2.0	25000	2.0	45000	2.0	60000	2.0	85000	2.0	100000	1.5	125000
15. Pathology of crown and root rots in apple.	2	0.5	15000	0.5	30000	0.5	45000	0.5	60000	0.5	90000	0.5	110000
16. Diseases of sugar crops.	2	-	-	-	-	-	-	0.5	20000	1.0	40000	1.5	80000
17. Resistance to Phytophthora spp. in stone and pome fruits.	2	-	-	-	-	-	-	0.5	20000	0.5	40000	1.5	65000
18. Maintenance of mycological herbarium.	2	1.0.	10000	1.0	15743	1.0	28084	1.0	44741	2.0	61429	2.0	88060
Total		25.0	630000	25.0	1015743	25.0	1468084	26.0	1864741	29.0	2481429	33.0	3633060

BUDGET						
Staff Costs: Existing (1988/89 + 3%/year)	2427024	2499835	2574830	2789611	3722143	5449589
Additional	0	0	0	137536	269515	346792
Operational Funds	630000	1015743	1468084	1859741	2481429	3633060
Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	3057024	3515578	4042914	4649351	6203571	9082649

* Number of Scientists (BP 17-20) 1 CSO, 1 PSO, 10 SSO, 13 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

PLANT VIROLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Identification and characterization of specific virus diseases infecting cereals, sugarcane, vegetables, citrus and papaya.	1	1.0	20000	1.0	30000	0.8	30000	0.8	48000	0.8	55000	1.0	75000
2. Ecology and epidemiology of important virus including assessment of losses.	1	0.5	10000	0.6	20000	0.4	30000	0.4	40000	0.4	50000	0.4	85000
3. Purification of important viruses, for the purpose of antisera production and Elisa kits (Potato, tomato, sugarcane and citrus).	1	1.0	25000	1.0	41000	0.6	55000	0.6	60000	0.6	80000	1.0	110000
4. Screening of varieties of barley, sugarcane, potat and tomato for resistance against viruses.	1	0.5	5000	0.4	10000	0.4	15000	0.4	20000	0.4	40000	0.4	65000
5. Investigation on legume viruses (chickpea, mung bean and peanuts) with respect to their accurate identity, mode of transmission and method of control	1	-	-	0.4	10000	0.4	10000	0.4	35824	0.4	57000	0.8	75000
6. Development of proper control measures of virus diseases.	1	1.0	10000	0.4	10000	0.6	16000	0.6	30000	0.6	35000	0.8	55000
7. Virus vector relationships and vector population dynamics of aphids and whitefly.	2	-	-	0.4	10000	0.6	25000	0.6	25000	0.6	25000	0.4	40000
8. Control of insect vectors of potato and chickpea through nuclear polyhedrosis viruses.	2	-	-	0.4	9621	0.4	12594	0.4	27000	0.4	30000	0.4	50000
9. Assistance in the development of production of virus-free material of potato, tomato, sugarcane and citrus.	2	1.0	10000	0.4	10000	0.4	20000	0.4	15000	0.4	15000	0.4	25000
10. Viroids and mycoplasma diseases of potato, sugarcane, citrus and sesamum.	3	-	-	-	-	0.4	20000	0.4	30000	0.4	28214	0.4	31140
Total		5.0	80000	5.0	150621	5.0	233594	5.0	330824	5.0	415214	6.0	611140

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	488508	503163	518258	533806	692199	1013448
	Additional	0	0	0	0	46251	64492
	Operational Funds	80000	150621	233594	330824	415214	611140
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	568508	653784	751852	864630	1153664	1689080

*Number of scientists (BP 17-20) 1 PSO, 1 SSO, 3 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

ENTOMOLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Estimation of losses caused by major insect pests at their given densities, and establishment of cultures of imp. natural enemies of major pests.	1	4.0	14000	4.0	59307	4.0	123000	3.0	125000	1.0	75000	2.0	172000
2. Dev of pest scouting and packages of IPM tech for insect pests of rice, sugarcane, maize, sorghum, oilseed crops, pulses, fruit and vegetables.	1	3.0	9500	3.0	41500	3.0	84500	3.0	131000	2.0	160000	1.0	95000
3. Study the ecology of storage losses due to insect pests in imp. food grains in central and northern Pakistan and development of effective fumigation techniques.	1	4.0	12000	4.0	56000	4.0	115000	3.0	142000	2.0	132000	1.0	92000
4. Survey of the insect pests of livestock & poultry, estimation of losses caused by them & development of effective control measures against them.	1	1.0	3000	1.0	15000	1.0	30000	1.0	50000	2.0	145000	3.0	295000
5. Screening of rice, sugarcane, maize, sorghum, pulses, oilseeds & cereal germplasm for resistance to insect pests.	2	3.0	9500	3.0	41000	3.0	83259	2.0	108379	2.0	141587	2.0	173414
6. Identification of strains and biotypes of major crop and stored grain pests resistant to insecticides and development of packages of technology for management of insecticide resistance.	2	3.0	8000	3.0	50000	3.0	80000	2.0	79000	2.0	128000	2.0	165000
7. Evaluation of fourth generation pesticides(viruses bacteria, protozoa, nematodes and botanical pesticides).	2	2.0	11000	2.0	40000	2.0	65000	2.0	105000	2.0	135000	2.0	180000
8. Determination of the side-effects of pesticides on non-target organisms, their role in environmental pollution and development of safe pesticides.	3	-	-	-	-	-	-	1.0	40000	2.0	140000	3.0	310000

continued

ENTOMOLOGY (continued)

Project Titie	Prior-ity	1988 / 89 Staff*	1988 / 89 Op.F**	1989 / 90 Staff	1989 / 90 Op.F	1990 / 91 Staff	1990 / 91 Op.F	1991 / 92 Staff	1991 / 92 Op.F	1992/93-1995/96 Annual average Staff	1992/93-1995/96 Annual average Op.F	1996/97-1999/00 Annual average Staff	1996/97-1999/00 Annual average Op.F
9, Development of computer models for forecasting population densities of insect pests in different ecological zones.	3	-	-	-	-	-	-	2.0	82000	2.0	142000	2.0	175000
10. Isolation, identification and integration of sex pheramones in IPM models.	4	-	-	-	-	-	-	1.0	45000	2.0	135000	2.0	185000
11. Identification of insect vectors of viral diseases, and development of techniques for their effective control.	4	-	-	-	-	-	-	-	-	2.0	130000	3.0	252000
Total		20.0	67000	20.0	302807	20.0	580759	20.0	907379	23.0	1463587	23.0	2094414

BUDGET							
	Staff Costs: Existing (1988/89 + 3%/year)	1881312	1937751	1995884	2055760	2390424	3473149
	Additional	0	0	0	0	99668	221019
	Operational Funds	67000	302807	580759	907379	1463587	2094414
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	1948312	2240559	2576643	2963139	3953679	5788582

* Number of Scientists (BP 17-20) 1 PSO, 4 SSO, 15 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

WEED SCIENCE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. a. Integrated weed management. b. Chemical weed control (Doses application of time and method, improving efficiency through tank mix, surfactents etc.) c. Developing ecological/cultural weed control methods such as cultural practices, water, fertilizer and light management, seeding time, seeding methods, mulching. d. Identifying biological weed control agents, pathogens/insects/herbivors for weed of economic importance. e. Allelopathy. f. Identifying seedicides, dormancy breakers, germinators and their possible use in weed management.	1	3.0	50000	3.0	100000	2.0	100000	2.0	150000	2.0	200000	2.0	250000
2. Biology of weeds of economic importance.	1	2.0	20000	2.0	45000	2.0	75000	2.0	100000	2.0	150000	2.0	200000
3. Response of weeds of economic importance to ecological factors.	2	1.0	10000	1.0	25000	1.0	50000	1.0	70000	1.0	100000	2.0	150000
4. Weed distribution in different ecological zones of Pakistan and weed dynamics under different cultural practices, cropping/farming systems.	2	1.0	10000	1.0	25000	1.0	40000	1.0	50000	1.0	100000	1.0	125000
5. Determining critical period of competition.	2	1.0	4000	1.0	18374	1.0	38812	1.0	48570	1.0	80000	1.0	119120
6. Herbicide persistance in the soil and plant/ toxicology.	3	-	-	-	-	1.0	50000	1.0	75000	1.0	70000	1.0	100000
7. Developing weed forecasting mathematical expressions.	3	-	-	-	-	-	-	-	25000	1.0	21394	1.0	100000
Total		8.0	94000	8.0	213374	8.0	353812	8.0	518570	9.0	721394	10.0	1044120

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	877284	903603	930711	958632	1182607	1731455
	Additional	0	0	0	0	67011	110103
	Operational Funds	94000	213374	353812	518570	721394	1044120
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	971284	1116977	1284523	1477202	1971012	2885758

* Number of scientists (BP 17-20) 1 PSO, 2 SSO, 5 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

VERTEBRATE PEST MANAGEMENT: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Studies on the biology and behaviour of wild boar, leading to development of toxicants, bait and bait delivery systems for control methods.	1	1.0	40000	1.0	51064	1.0	60000	1.0	60000	1.0	80000	-	-
2. Demonstrate existing technologies on the control of rodents in wheat and rice through operational research in different agro-ecological zones.	1	1.0	40000	1.0	60000	1.0	61496	1.0	58645	1.0	80000	1.0	150000
3. To develop vertebrate pest control technologies onward transmission to FSR/farmers, CMP program, BARD etc.	1	1.0	40000	1.0	52000	1.0	60000	1.0	50000	1.0	80000	1.0	150000
4. Studies of the stability of several rodenticides under local environmental conditions.	1	1.0	30000	1.0	40000	1.0	50000	-	-	-	-	-	-
5. Development of vertebrate pest control methods for sugarcane.	2	-	-	-	-	-	-	0.3	40000	0.5	50000	-	-
6. Lab and field evaluation of various toxicants, repellents, bait materials and formulations against major vertebrate pests.	2	-	-	-	-	-	-	0.4	50000	0.5	50000	-	-
7. Development and evaluation of pre-harvest damage assessment methods.	2	-	-	-	-	-	-	0.3	40000	0.5	65297	-	-
8. Study the fluctuation of rat population with rotation of crops and seasons in dif. agro-ecosystems.	2	-	-	-	-	-	-	-	-	0.5	65000	-	-
9. To study the biology of parakeet and other major bird pest species affecting cereal and oilseed crops, fruit orchards and evaluate effective control techniques.	3	-	-	-	-	-	-	-	-	-	-	1.0	125000
10. Porcupine biology, ecology in croplands & forestry areas and to evaluate various toxicants/fumigants for control.	4	-	-	-	-	-	-	-	-	-	-	1.0	125000

continued

VERTEBRATE PEST MANAGEMENT (continued)

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
11. To assess the economic losses and to develop the control methods on Pika, Murree vole and other vertebrate pests in fruit orchards of mountainous valleys of Punjab, NWFP and Baluchistan.	4	-	-	-	-	-	-	-	-	-	-	0.5	65000
12. To study the cost/benefit ratio of various control techniques of vertebrate pests in different crops.	4	-	-	-	-	-	-	-	-	-	-	0.5	67444
13. Development of technology transfer and outreach materials for use by agriculture extension workers to disseminate new knowledge to farmers.	4	-	-	-	-	-	-	-	-	-	-	0.5	60000
14. Development of technology and transfer of extension and outreach materials for grain storage management situations.	4	-	-	-	-	-	-	-	-	-	-	0.5	50000
Total		4.0	150000	4.0	203064	4.0	231496	3.0	298645	5.0	470297	6.0	792444

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	254700	262341	270211	278318	315275	454040
	Additional	0	16902	33509	38536	35679	45910
	Operational Funds	150000	203064	231496	298645	470297	792444
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	404700	465405	535216	615498	821251	1292394

* Number of scientists (BP 17-20) 1 SSO, 3 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

ANIMAL SCIENCES

Animal Breeding and Genetics

With the exception of a few dairy breeds, most of Pakistan's bovine population is composed of low producing nondescript animals. To cope with the feed shortage and increasing demands for livestock products, genetic improvement of cattle and buffalo is highly desirable. Crossbreeding local cattle with exotic semen and progeny selection in buffaloes are appropriate strategies for genetic improvement, which can only be accomplished through relevant on-station research, application of research results in the field and monitoring of the progress made. A nucleus herd of Jersey cows imported from USA in 1985 is being maintained at the Animal Sciences Institute for performance evaluation under local conditions, as well as for the production of superior germplasm for the crossbreeding programs. Experimental crossbreeding between Jersey and nondescript cattle in the Islamabad district has had promising results.

Major production problems are:

- Deterioration in the productivity of established breeds of dairy cattle, such as Sahiwal and Red Sindhi, due to improper selection and non-scientific breeding practices.
- Late maturity, long calving intervals, and low production potential of nondescript cattle.
- Lack of high quality germplasm and inadequate facilities for massive genetic improvement at the small farmer level.
- Lack of knowledge on adaptability, growth, semen quality,and producing abilities of crossbred cattle for selected ecological zones.
- Seasonal shortage of fodder, forage varieties, and little recycling of crop residues and other wastes.
- Lack of a data recording system. Livestock registration is important for further genetic improvement.

Goals and objectives. The principal aims of the animal breeding and genetics programme are:

- To introduce suitable exotic breeds of dairy cattle.
- To provide high yielding animals adapted to local environmental conditions.
- To upgrade native cattle in Islamabad district through crossbreeding.

Mandate. The Animal Sciences Institute, which includes animal breeding and genetics, is to conduct problem-oriented research on animal health and production to develop efficient feeding, management, and disease-control measures in order to optimise animal productivity. The animal breeding program at NARC is responsible for the production of superior animals. The coordinator of the program is based at PARC. As a part of its mandate, the program envisages genetic improvement of livestock through selection based on quantitative traits or crossbreeding with suitable exotic breeds.

Current programme. Animal breeding work which is being carried out at NARC relates particularly to the public needs in the Islamabad district. Upgrading local cows in the district through crossbreeding with Jerseys, critical evaluation of the performance of such crossbreds at the farmer level, and comparison with that of pure Jerseys at the NARC station aims at studying adaptability, measuring potential for genetic improvement under local management and climatic conditions, and noting changes in the expression of quantitative traits. Genetic improvement of nondescript cattle has definite merit since improved nutrition alone will not suffice in this low yielding (only 1 to 3 litres of milk per day), diversified population of cattle.

Proposed programme

Priority 1

- Performance evaluation of the existing herds of Jersey cattle and Nili-Ravi buffaloes maintained at ASI.
- Production of superior cattle and buffalo germplasm through selective breeding.
- Upgrading of native cattle in Islamabad district through crossing with Jersey semen.
- Studies on pre-weaning and post-weaning growth parameters in cattle and buffalo calves.

Priority 2

- Studies on genetic and non-genetic factors affecting fertility in cattle and buffalo.
- Studies on genotype x environment interactions.

Priority 3

- Studies on pre-weaning and post-weaning growth parameters in cattle and buffalo calves.

Linkages and relationships. The animal breeding program collaborates with animal health, animal nutrition, reproductive physiology, embryo transfer, farm management, statistics/computer science personnel, and the transfer of technology unit. The animal breeding program at NARC will be related to other provincial centres through the proposed national coordinated project on dairy cattle crossbreeding and will follow the agreed-upon breeding plans in the Islamabad district. The animal breeding program at NARC will be related to site-specific work being conducted elsewhere such as LPRI, Bahadurnagar, and the agricultural universities.

Expected accomplishments

- A scientific basis will be developed for judging the suitability of exotic Jersey cattle in terms of their performance and adaptation to local climate.
- The cattle and buffalo population will be improved through production of superior germplasm, particularly in Islamabad district.

Reproductive Physiology

Several factors cause low productivity in buffaloes. Among them, are late maturity, higher age of first calving, longer calving interval, repeat breeding, anoestrus, and marked seasonal variation in breeding. It is established that the older a heifer is at the time of puberty and the longer it takes from parturition to next conception, the lower will be lifetime production of animal.

Pakistani buffaloes are 4 to 5 years old before first freshening and their calving interval ranges from 18 to 23 months. These two problems cause huge economic losses to the livestock economy. According to a survey, 24 billion rupees are lost every year due to late freshening age and 37 billion rupees from long calving interval. By lowering the age at first calving to 28 months and shortening the calving interval to 13 months, two additional lactations from an individual buffalo can be taken by the age of 11 years. Some basic research conducted on this species indicate that these targets can be achieved by improving the nutritional status of growing heifers and by applying the modern practices of reproductive management in adult buffaloes.

Specifically the major reproductive problems are:

- Delayed puberty shortens the productive life span of indigenous cattle and buffaloes.
- Lack of information on physiological mechanisms involved in the onset of puberty in buffaloes.
- Long calving interval in buffaloes.
- Problems associated with detection of estrus in buffaloes.

- Lack of information on time of ovulation relative to onset of estrus and optimum time of insemination in buffaloes.
- Problem of irregular re-establishment of ovarian functions and estrus, cyclicity in postpartum buffaloes.
- Lack of suitable processing and preservation technology for buffalo semen.
- Incomplete information on various environmental and nutritional factors affecting semen producing ability of buffalo and crossbred bulls.

Goals and objectives. The principal aims of the reproductive physiology are:

- To improve reproductive efficiency of cattle and buffalo through research on various physiological aspects of reproduction.
- To shorten the calving interval and lower the age at maturity in buffaloes by manipulating physiological and management factors.
- To improve the preservability and fertilizing ability of buffalo semen.
- To establish various reproductive and physical indices for selection of early maturing sires and increase sperm output and quality.

Mandate. Animal Sciences Institute, which includes reproductive physiology, is to conduct problem-oriented research on animal health and production to develop efficient feeding, management, and disease-control measures to optimise animal productivity.

Current programme. In reproductive physiology, a number of studies are carried out with the object of increasing the reproductive efficiency of buffaloes and to improve preservability and fertilizing ability of buffalo semen.

Proposed programme. Experiments on different factors in relation to longer calving interval, delayed age at puberty, silent heat, anoestrus, levels of hormones in females and poor quality of frozen buffalo semen and of cross-bred cow bull semen will be conducted during the next 12 years.

Priority 1

- Factors affecting post-partum reproductive performance in buffaloes.
- To find effective ways to diagnose pregnancy at an early stage and to detect oestrus in silent buffaloes.

Priority 2

- Endocrinological studies in buffalo bulls with special reference to hastening puberty.
- Studies on biochemical aspects of buffalo semen and to develop appropriate extender for its preservation.

Priority 3

- Identification of causes of poor quality semen in crossbred cow bulls and to improve its fertilizability.
- Pubertal development in buffalo heifers with reference to nutrition, management, and endocrinological aspects.

Linkages and relationships. On campus the reproductive physiology section will require participation from the animal nutrition laboratory and the embryo transfer laboratory. Collaborating provincial centres are Semen Production Unit, Qadirabad, for semen studies on buffalo bulls and Livestock Production Research Institute, Bahadurnagar, for studies on factors affecting post-partum period in buffaloes. Other Pakistani centres involved are University of Agriculture, Faisalabad for fertility trials; Veterinary Research Institute, Peshawar, for enzyme immuno assays; and Quaid-i-Azam University for estimation of reproductive hormones.

Expected accomplishments

- Studies on post-partum reproduction will reduce the calving intervals in buffalo to 13-14 months.
- Easy, reliable and accurate procedures and methods will be available for diagnosing pregnancy at the earliest stages i.e. 30 days in buffaloes under farm conditions.
- Better criteria for detection of estrus in buffaloes and silent buffaloes will be available. This will significantly improve breeding management.
- The pubertal age in buffalo heifers under optimal conditions of feeding and management (expected 25 months) and under high energy ration and improved management (expected 20 months) will be established. The growth, reproductive, and endocrinological data will help in establishing suitable criteria for selection of buffaloes at the minimum age of puberty.
- Puberty and sexual maturation processes in buffalo bulls will be hastened through neuroendocrine perturbations which may allow augmentation of reproductive capacity (e.g. increase sperm production or accelerate puberty).
- Based on biochemical studies, a suitable extender for optimum preservation of the fertilizing ability of buffalo spermatozoa will be available.

Embryo Transfer

Reproductivity of valuable female cattle and buffaloes can be increased to a great extent by superovulation and subsequent transfer of embryos to low-producing recipients. In this way there is scope for more intense selection, accelerated genetic improvement, and rapid multiplication of superior stock. In parts of the world where this technique is used, on an average, 10 live calves can be obtained per year from one elite cow. Elite specimens from renowned dairy breeds of Pakistan like Sahiwal and Red Sindhi can be multiplied rapidly through application of embryo transfer.

Poor reproductive efficiency of buffaloes due to long calving interval and late age at maturity is well known. Embryo transfer would allow progeny from elite and high yielding animals to be spread at a rapid rate to replace scrub animals. Embryo transfer work would also increase understanding of the reproductive physiology of this species.

Major production issues related to the embryo transfer programme are:

- Limited number of elite dairy cows and buffaloes.
- Inefficient delivery of larger number of calves from elite animals.
- Low milk production potential of nondescript cows and buffaloes.
- Lack of selective breeding programme at the farmer level.

Goals and objectives. The principal aims of the embryo transfer programme are:

- To establish embryo transfer technology in local cattle (Sahiwal and Red Sindhi).
- To develop methods and techniques for successful embryo transfer in buffaloes.
- To study norms of reproductive physiology of buffaloes by using embryo transfer as a research tool.

Mandate. Animal Sciences Institute, NARC, which includes embryo transfer is to conduct problem-oriented research in the field of animal health and production to develop efficient feeding, management, and disease-control measures in order to optimise animal productivity. Advanced research will be carried out as needed.

Current programme. In the area of embryo transfer, various superovulatory treatments and regimens are being explored with respect to their impact on recovery and transfer of embryos in cows and buffaloes.

Proposed programme

Priority 1

- Superovulatory and endocrine responses in cattle and buffaloes with PMSG and FSH.
- Study of factors affecting superovulation response and embryo recovery in buffaloes.
- Cryo-preservation of cattle and buffalo embryos.

Priority 2

- Embryonic development in buffaloes.
- Microsurgery of cattle and buffalo embryos.

Priority 3

- In vitro culture and sexing of embryos.

Linkages and relationships. Embryo transfer work has collaborative linkages with reproductive physiology and animal nutrition at the NARC campus and with Quaid-i-Azam University, Islamabad, and Reproductive Physiology Institute, Pattoki. Training courses will be arranged for provincial scientists and the method developed will be imparted to them to practice at the farmer level.

Expected accomplishments

- Techniques of embryo collection, preservation, splitting, and transfer of cattle embryos will be perfected and extended to extension workers.
- Superovulation regimen and embryo recovery methods will be established in buffaloes.
- Cryopreservation of buffalo embryos will be standardized.

Meat Production

Meat production in Pakistan is a sideline enterprise, the potentiality of which has hardly been touched. It has been estimated that exploiting surplus male calves could increase beef production by 0.5 million tonnes and an additional 50,000 tonnes of mutton could come from young kids and lambs. The major calf crop and small ruminants are underfed and undernourished from birth, so their growth and development is stunted. Large and small ruminants research is needed to investigate the growth and meat production potentials under optimum management conditions and organizing and management of feedlot raising of meat animals.

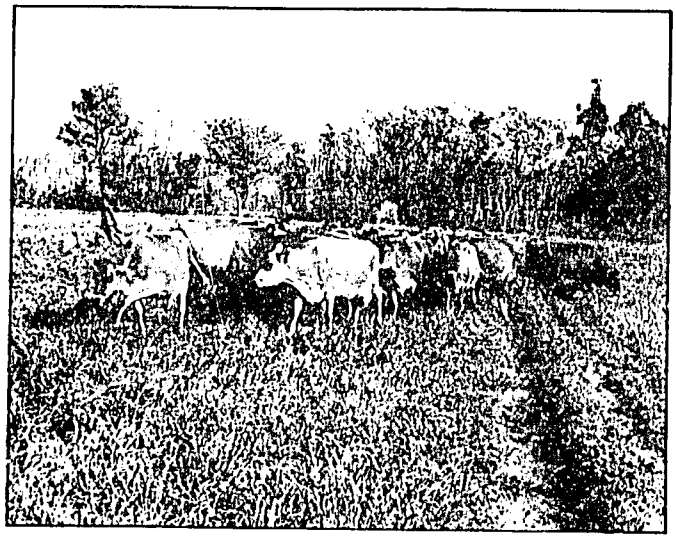
The lack of a suitable carcass-grading system hinders the development of the meat industry. A carcass-grading system suitable to Pakistani conditions would benefit producers increasing demand from local and foreign markets and leading to higher payment for better quality meat. Meat traders and retailers would benefit by the efficient handling of well classified units and thus by increased turnover; and consumers would benefit by being able to select the quality they want.

In addition little benefit is derived from slaughterhouse by-products. Methods should be worked out to use slaughterhouse by-products and wastes in a manner favourable to environment. The complete utilization of by-products will help slaughterhouses meet operating expenses and will result in lower prices of meat.

Specific production problems are:

- Unknown beef production potential of buffaloes and local breeds of cattle.
- Need to improve slaughtering, handling, and marketing of meat.
- Unknown meat production potential of different local breeds of sheep.
- Unknown age/weight relationship of buffaloes and goats for optimum meat production.

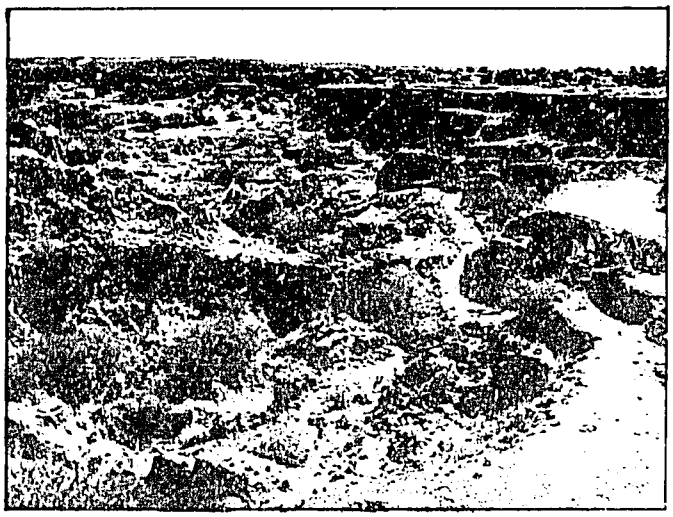
The development of improved fodder and grazing practices enables agrostologists working with animal scientists to raise milk production through low cost quality fodder.



Biotechnology is used by animal scientists as an alternative to traditional breeding. An embryo transfer technique is used to transfer desirable genes, then rear and select superior livestock.

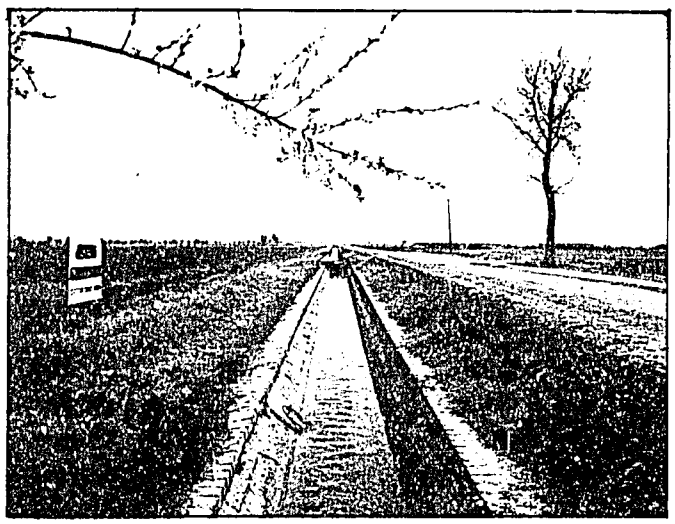
Detailed knowledge as to when the buffalo comes in heat has enabled NARC scientists to reduce calving intervals and help farmers manage their herds economically.

The embryo transfer technique has been successfully employed by NARC scientists to produce high quality calves using the non-descript low quality cows as surrogate mothers.

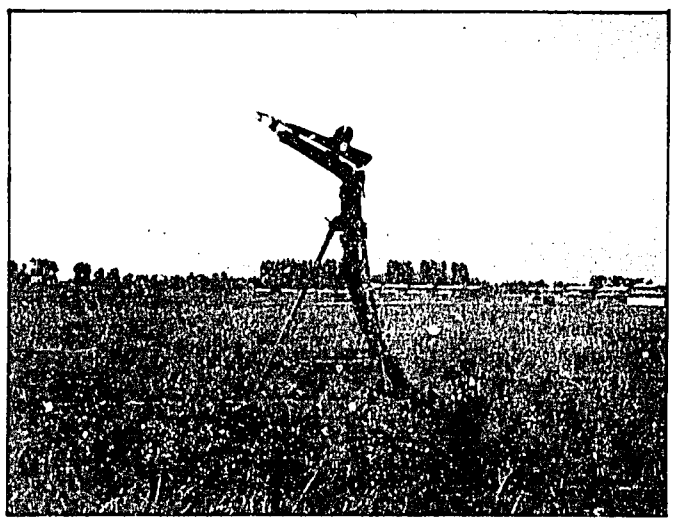


Agro-forestry provides an attractive alternative for farmers as a source of livestock feed and fuel wood. At the same time, agro-forestry protects soil against erosion which is often associated with overgrazing by goats.

Lining of canals and watercourses reduces seepage losses and is particularly important in rainfed areas where supplemental irrigation is used.



In studies on the reclamation of eroded lands, NARC scientists have developed land use practices which reduce soil and water loss and sustain productivity.



Rain gun sprinkler system has been fabricated by NARC scientists to irrigate small farms and orchards, where water is scarce or irrigation in not easily possible.

Goals and objectives. The overall objective of the meat programme is to increase quantity and quality of meat for human consumption and for export, thereby increasing the income of farmers and improving the nutritional status of masses. The specific objectives are:

- To develop production technologies for optimizing the productivity of mutton and beef.
- To develop appropriate and efficient methods for meat handling, transportation, and storage in order to enhance quality.
- To develop efficient technologies for slaughterhouse by-products handling and utilization.

Mandate. The Animal Sciences Institute, NARC which includes meat processing is to conduct problem-oriented research in the field of animal health and production to develop efficient feeding, management, and disease-control measures to optimise animal productivity.

Current programme. A number of studies have been conducted on the influence of growth promoters on growth, carcass traits, and meat quality of buffalo calves, on the beef production capabilities of calves raised in feedlots vs. traditional grazing, on the mutton production potential of Kajli lambs, and on microbiological aspects of meat at different stages of processing and handling.

Proposed programme

Priority 1

- Studies on meat production capabilities of local sheep breeds.
- Development of feedlot systems for economical beef and mutton production.
- Studies to determine economical age/weight relationships for meat production by small and large ruminants.

Priority 2

- Characterization and standardization of physical, bacteriological, chemical properties during handling and preservation (packing), and development of a carcass grading system.

Priority 3

- Studies on the efficient utilization of slaughter house by-products and waste.

Advanced research. Specialized investigations on different muscle components such as proteins affecting meat tenderness and methods for improving the quality of meat will be undertaken.

Linkages and relationships. The meat production programme will have close linkages and relationship with national programmes on animal nutrition, animal health, and sheep and goats and with the agricultural economics research unit. The project will work closely with various ongoing programmes on livestock production in the provinces and at other Pakistani centres where specific meat research is in progress. The meat project will have close contact with international meat research centres such as the Meat Research Centre, Kulmbach, West Germany; Meat Research Institute, Bristol, England; and American Meat Research Association.

Expected accomplishments

- The optimum age and feeding schedules for economical beef and mutton production in Pakistan will be established.
- By-product utilization will reduce the cost of meat.
- Parameters for a carcass-grading system suitable for Pakistan will be developed.

Dairy Technology

Average per capita availability of milk and milk products in Pakistan is relatively high as

compared with other countries of the region. But milk is unevenly consumed by rural and the urban populations due to lack of organized facilities for milk collection, processing, and marketing. The problems of milk production, collection, processing, and marketing are complex and the situation cannot be improved without systematic research in the field of dairy technology. Major production problems are:

- Milk losses due to insufficient milk collection, processing, and distribution system.
- Lack of suitable technology to improve indigenous methods of preparation of milk products for better utilization of milk at the farm level.
- Poor quality dairy products associated with unhygienic milk handling during processing and distribution.
- Improper and inadequate use of modern technology resulting in low quality dairy products.

Goals and objectives. The principal aims of the dairy science programme are:

- To develop appropriate methods to improve the keeping quality of milk.
- To improve indigenous methods of dairy products manufacturing.

Mandate. The Animal Sciences Institute, which includes dairy science, is to conduct problem-oriented research in the field of animal health and production to develop efficient feeding, management, and disease-control measures in order to optimise animal productivity.

Current programme. Studies have been carried out on the quality of milk supplied by different sources at different intervals of its distribution in Islamabad. Also studies on milk processing, such as yoghurt making, selection of starter culture, and preservation of raw milk have been initiated.

Proposed programme

Priority 1

- To develop a technology for the preservation of milk and preparation of milk products at farm level.
- Study the microbiological aspects of dairy products in reference to public health.

Priority 2

- Development of starter culture production and propagation techniques for the improvement of indigenous fermented milk products.
- Use of different enzymes for appropriate utilization of various milk components.

Linkages and relationships. On campus, the dairy technology section will provide supporting services to animal breeding and genetics, Animal Sciences Institute dairy farm, animal nutrition, and food quality laboratory. Analytical services for milk and milk products can be provided to provincial livestock departments.

Expected accomplishments

- An improved method of milk collection for Pakistani rural conditions will be developed, overcoming the main obstacle for the supply of milk to urban centres.
- Indigenous technology for the manufacturing of milk products will be available for use by the farmers and rural industry.

Poultry

Poultry, the fastest converter of crude nutrients into high quality of animal proteins, offers one way to overcome Pakistan's shortage of proteins of animal origin. The increase in population of poultry in Pakistan has averaged 16% a year during the last 10 years. At present, there are 16 million broilers and 6.9 million layers in addition to 44 million desi layers and cocks. A number of

breeds have to be imported regularly for multiplication and supply to private farms. Testing of the production performance of exotic breeds is needed to identify high producing species so farmers can chose the best breeds. The major production problems are:

- Inadequate information about imported broiler strains under local environmental and managemental conditions.
- Low productivity due to poor poultry husbandry.

Goals and objectives. The principal aims are:

- To evaluate different strains and breeds of commercial broilers and layers for optimum production under Pakistani conditions.
- To establish a centre for regular evaluation of poultry strains and breeds.
- To identify strains and breeds of broilers having superior carcass and meat quality.

Mandate. The Animal Sciences Institute, which includes the poultry programme, is to conduct problem-oriented research in the field of animal health and production to develop efficient feeding, management, and disease-control measures in order to optimise animal productivity.

Current programme. Current work consists of performance testing of various commercial broiler strains and commercial layer strains.

Proposed programme

Priority 1

- Performance testing of various commercial broiler strains of poultry in Pakistan.
- Study of meat quality of various poultry strains and breeds.
- Studies on various management aspects of poultry.

Priority 2

- Performance testing of various layer strains of poultry in Pakistan.

Linkages and relationships. On campus, the poultry programme collaborates with the meat project and animal nutrition. Consultations are also being carried out with poultry scientists at the Poultry Development Centre and Barani College.

Expected accomplishments

- Regular evaluation of commercial broiler strains and layer strains will be available for the poultry trade and farmers.
- Improved housing for poultry raised in the Islamabad and Rawalpindi area will be available for farmers.

Animal Nutrition

Livestock production is critically dependent on the availability of quality feedstuffs. In Pakistan shortages of traditional fodder and forages, particularly the energy and protein concentrates, adversely affect livestock productivity. The shortage of energy and proteins from the available feed resources is about 29 and 3 percent, respectively, relative to the nutrient requirements of the livestock population at its present production potential.

According to a recent estimate, however, about 60 million tonnes of unconventional feed resources, mainly crop residues, agro-industrial by-products, and animal wastes are available in Pakistan. These potential feedstuffs represent a vast reservoir of cheap nutrients convertible into milk and meat. For efficient utilization, their digestibility and palatability have to be improved. The policy to develop and utilize these resources represents a vital component in the national strategy for feed production.

The major nutritional problems affecting production are:

- Short supply of traditional fodder and forage, and seasonal fluctuations in supply.
- Lack of quality feedstuffs particularly the energy and protein concentrates (grain and oilseed cakes).
- Inferior feeding management systems for different species of livestock at various production levels.
- Inadequate use of silage or hay feeding during feed-stress periods.
- Inadequate technology for, or improper utilization of, agro-industrial wastes and byproducts for livestock feeding.
- Minimal use of formula feed mix to optimise livestock performance.
- No quality control system on feed (nutritive value and toxicology).

Goals and objectives. The principal aims are:

- To harness the large reservoirs of crop residues, agro-industrial by-products, and animal wastes for utilization in livestock feeding.
- To identify feasible systems for farmers, commercial feed millers, and agro-industries to produce economical and balanced ruminant feeds.
- To establish national analytical standards for evaluating the nutritive value of feeds.

Mandate. The Animal Sciences Institute, which includes animal nutrition, is to conduct problem-oriented research in the field of animal health and production to develop efficient feeding, management, and disease-control measures in order to optimise animal productivity.

Current programme. Of 11 currently active projects, 4 examine the potential role of urea in feeding of various kinds of livestock, 3 analyze the nutritive values of crop residues and plants, 3 are specialized feeding trials, and 1 is a microbial study of fish raised on biogas effluents. The animals used in the experiments, are buffalo heifers, sheep, and fish.

Proposed programme

Priority 1

- Development, identification, and adaptation of suitable technologies to enhance the nutritional value of agricultural wastes and industrial by-products for production of complete least-cost formula rations.
- Development of suitable technologies to produce solidified multinutrient urea-molasses blocks, briquettes, pellets, liquid supplements etc., on a least-cost principle for diverse ecological farming systems, and verification of these products in feeding trials.
- Research on the use of various additives to increase the nutritional value of silages.
- Digestibility and nitrogen-balance trials on sheep for the evaluation of nutritive value of various types of green fodder, hay, and silage.

Priority 2

- Development of efficient and economical processing methods for the utilization of poultry litter and animal wastes in livestock feeding.
- To establish the nutrient requirements of various classes of livestock.
- Evaluation of unconventional protein and energy supplements for livestock feeding.
- Studies on the change in quality and nutrients availability during processing and storages of feed stuffs and compound feeds.
- Studies on the mineral metabolism in lactating animals.
- Evaluation of feed lot systems for mutton and beef production based on complete least-cost rations.

Priority 3

- Manipulation of rumen ecosystem for maximum utilization of feed resources in livestock production.
- Comparative estimation of feeds for by-pass protein (rumen undergraded protein) with in-vivo and in-vitro techniques.
- Studies on the economical formulation and efficient utilization of milk replacers and early weaning diets.
- Standardization of various analytical techniques for the routine analysis of feedstuffs.

Linkages and relationships. On campus, the animal nutrition programme will take part in interdisciplinary coordination with various ASI programmes and collaborate with the fodder and forage programme; wheat, rice and maize programs; range management and forestry; and technology transfer unit. Collaboration will also be maintained with the following provincial centres: Poultry Research Institute, Rawalpindi; NWFP Agriculture University, Peshawar; VRI, Peshawar; PCSIR Laboratories, Lahore; Sind Agriculture University, Tandojam; Department of Animal Husbandry, AJK, Muzaffarabad; and with universities and other research institutes where advanced research in animal nutrition is in progress, including biotechnology studies.

Outside Pakistan, collaborative relationships have been established with Department of Animal Sciences, Virginia Polytechnic Institute and Department of Range Management, Oregon State University.

Expected accomplishments

- Appropriate rural and industrial technologies for upgrading the nutritional value of crop residues and industrial wastes and by-products will be developed. As a result, feasible systems for the production of economical and balanced ruminant feeds will be identified and disseminated to farmers, commercial feed millers, and agro-industry. Livestock productivity is expected to increase by about 40 percent.
- Least-cost ration formulation and analytical services on the nutritional evaluation of feedstuffs will be developed.
- Complete formula feeds and urea-molasses block manufacturing technology will be available and propagated for various livestock feeding systems.
- Feedlot systems for mutton and beef production will be established.
- Processing methods for the detoxification, preservation and storing of feeds and feedstuffs will be developed.
- With the establishment of nutrient requirement of various classes of livestock, an optimum feeding system will be developed.
- The introduction of milk replacers in early weaning diets will make 20% more fresh milk available for human consumption and increase meat production 50%.
- National analytical standards for evaluating the nutritive value of feeds will be established.

Animal Health

Animal diseases cause enormous economic losses through mortality and decreased production in Pakistan. The continual influx of diseased wild and domestic animals across the country's vast land borders, lack of research, and scarcity of material and technical manpower resources have forced the adoption of a policy of disease-control through vaccination rather than eradication through slaughter. As a result, almost all known diseases of animals are widely prevalent. Recently, a serious situation has arisen with the import of high-yielding exotic cattle,

sheep, and poultry breeds. Because these breeds are highly susceptible, they readily succumb to prevalent diseases. Moreover, new diseases are being introduced in the country along with the exotic breeds, especially of poultry.

The veterinary profession in Pakistan is ill-equipped to meet the challenge. The provincial veterinary research institutes are engaged mainly in the production of vaccines and other biological products. Limited research on livestock disease has been carried out at the three veterinary teaching institutions at Faisalabad, Lahore, and Tandojam.

Major animal health problems affecting production are:

- Poor immunogenicity of available biologics.
- Lack of facilities for isolation and identification of animal viruses.
- Inadequate knowledge of the epidemiology and pathogenesis of major Pakistan livestock diseases.
- Widespread use of traditional technology for animal disease diagnosis and control.
- Inadequate control measures against livestock diseases.

Goals and objectives. The principal aims of the animal health programme are:

- To improve vaccines and other prophylactic measures against major livestock diseases
- To develop cost-effective, rapid and accurate diagnostic methods for animal diseases.
- To study on newly emerging diseases of livestock and poultry in Pakistan.
- To elucidate the pathogenesis of major livestock diseases of Pakistan.

Mandate. Animal Sciences Institute, which includes animal health, is to conduct problem-oriented research in the field of animal health and production to develop efficient feeding, management, and disease-control measures in order to optimise animal productivity.

Current programme. The current program includes improvement of vaccine against haemorrhagic septicaemia, research on etiology, diagnosis, pathogenesis and control of Hydropericardium disease in poultry, studies on the epizootialogy and pathogenesis of Amphistomiosis in cattle and buffaloes, and diagnosis and control of subclinical mastitis in cattle and buffaloes.

Proposed programme

Priority 1

- Improvement of haemorrhagic septicaemia vaccine.
- Development of a combined vaccine for haemorrhagic septicaemia and foot and mouth disease.
- Identification of types and subtypes of animal viruses.
- Assessment of economic losses due to animal diseases.
- Development of prophylactic measures against haemoprotozoan ecto- and endo-parasites.
- Studies of pathogenesis of haemorrhagic septicaemia in cattle and buffaloes.
- Diagnosis, pathogenesis, and control of newly emerging diseases.

Priority 2

- Control of mastitis in the cattle and buffaloes.
- Development of diagnostic tests for mycoplasmosis and improvement of caprine pleropneumonia vaccine.
- Studies of pathogenesis of haemoprotozoan diseases of cattle and buffaloes.
- Development of monoclonal antibodies against animal pathogens.

Priority 3

- Pakistan culture collection program.
- Studies of the immunology of the buffalo.

Advanced research. Advanced research on the causative agents of disease, e.g. bacteria, viruses, etc. and isolation of specific antigens and production of monoclonal antibodies is being conducted. Also, pathogenesis of diseases specific to this region is being elucidated.

Linkages and relationships. The scientists at ASI utilize facilities available in other programs at NARC especially for analytical work, ultracentrifuge, electron microscope, etc. Facilities and technical advice available at ASI are provided to scientists in other programs at NARC. Collaborative research is being conducted at provincial centres including VRI, Lahore; VRI, Peshawar; and College of Veterinary Sciences, Lahore. Facilities available at other Pakistani centres are extensively used. These include National Institute of Health, Pakistan Atomic Energy Commission, PCSIR, etc. At present the linkages with international centres are limited to advanced training of ASI scientists. These scientists attend educational courses at these centres and conduct thesis research at ASI.

In the area of technology transfer, diagnostic and treatment service is being provided to livestock owners in the Islamabad Capital Territory, training courses are conducted and on-job training is provided to scientists in the provinces, and information on diagnosis, treatment, and control of animal diseases is disseminated through printed material, and radio and T.V. programs.

Expected accomplishments

- New and improved vaccines will be available for the control of the most important diseases of Pakistan.
- Information will be available for the control of many bacterial, viral, and parasitic diseases prevalent in Pakistan.
- Monoclonal antibody technology will be established in the institute and will replace the conventional sera at least for foot and mouth disease virus.
- Parameters of immune system in the buffalo will be known for further improvement of disease resistance in this species.
- Methods for the control of Hydropericardium in poultry and other emerging diseases will be developed for use in the field.

Sheep and Wool

Sheep production has been a seriously neglected area of research and development in Pakistan. To improve wool and mutton production, extensive fodder and forage production is needed, besides genetic improvement. The latter can be accomplished through selection in local breeds and cross breeding with suitable exotic breeds for which studies on adaptability and environmental interaction with production are essential. Specifically the major production problems are:

- Low production potential of local sheep breeds.
- Poor productivity of rangelands due to drought or mismanagement.
- Inadequate sheep husbandry technology for increasing production.

Goals and objectives. The principal aims of the sheep and wool programme are:

- To improve the quantity and quality of carpet wool and mutton production potential of sheep.
- To develop an effective and efficient management (feeding, breeding, and management) system to optimise productivity of meat and wool.

Mandate. The Animal Sciences Institute, which includes the sheep and wool programme, is to conduct problem-oriented research in the field of animal health and production to develop

efficient feeding, management, and disease-control measures in order to optimise animal productivity.

Current programme. The current programme aims at evolving fine wool sheep through crossbreeding, breeding of sheep for increased mutton and carpet wool production, documentation of genetic characteristics of sheep in Pakistan, utilization of agro-industrial by-products, and establishment of winter-active pastures in temperate and semi-temperate zones of Pakistan.

Proposed programme

Priority 1

- Production potential appraisal of various breeds of sheep.
- Improving the productivity of sheep through crossbreeding and selection.
- Genetic and non-genetic factors affecting fertility and prolificacy of sheep.
- Maximization of productivity in sheep through improved management systems.

Priority 2

- Studies on the improvement of fleece characteristics.
- Study the physiological aspects of adaptability in exotic and crossbred animals.

Linkages and relationships. At NARC the sheep and wool project will require participation from animal health, animal breeding and genetics, animal reproductive physiology, agriculture economics, animal nutrition, and farming systems research. The following units of the provincial governments will participate as coordinating units of the project. Bahadurnagar (Punjab), Tandojam (Sind), Maslak (Baluchistan), Jaba (NWFP), and Khawarmang (AJ&K). Tandojam University also plays an active role in research collaboration. Cooperation in technological innovations under FAO's Near East Regional Cooperative Research and Development Network on Small Ruminants will be established.

Expected accomplishments

- Through crossing native sheep with exotic ones, a sheep breed suited to rainfed areas surrounding Islamabad will be developed. Crossing will be practised to the extent that native breed retains hardiness characteristics and remains adapted to the local climatic conditions. This crossing will not only improve the quality and quantity of wool but also productive traits, leading to increased mutton production in the region.
- Research on feeding and management of sheep will lead to methods for economical sheep production in the country.

Goat Production

Goats provide 25% of the total meat supply and are an important source of income for small farmers. Research on goat production has been neglected in spite of the importance of this species. Realizing this the government has begun a national coordinated project to conduct research on various aspects of goat production. The major production problems are:

- Unknown production potential of different breeds of goats.
- Need to improve genetic potential of local goats.
- Need to evolve better nutritional and management practices for optimisation of goat production under local conditions.

Objectives. The principal aims of the goat production programme are:

- To improve the production and reproductive capabilities of goats through improved nutrition, management, and genetics.
- To study the goat production pattern in the country with emphasis on economics, marketing, and social aspects.

Proposed programme

- Genetic appraisal of various breeds of goats in Pakistan.
- Improving the productivity of goats through crossbreeding and selection.
- Genetic and non-genetic factors affecting fertility and prolificacy of goats.
- Effect of feeding and grazing regimes on mutton and milk production in goats.
- Maximization of productivity in goats through improved management, housing, and health coverage.

Expected accomplishments

- Production of meat from goats will be 20 percent greater than the present level. This increase is valued at about Rs 1 billion. Greater production of milk, hair, and skins from goats will be an extra benefit.
- A package of practices relevant to the needs of farming community will be devised.

Fisheries

Research in Pakistan so far has largely focused on marine resources development. Little attention has been paid to freshwater fisheries although Pakistan is endowed with extensive inland water resources. In 1986 a functional research laboratory with allied pond facilities was established in NARC, which has emerged as one of the biggest research centres in the country for freshwater fisheries research. The major production problems are:

- Inadequate water supply for fish culture.
- Shortage of brood fish for artificial propagation.
- Non-availability of spawner shrimps or commercial feeds for fish and shrimp aquaculture.
- Non-availability of suitable netting material for fishing.
- Improper handling of fish and shrimps.

Goals and objectives. The principal aims of the fisheries programme are:

- To increase fish production per unit area under various farming systems to improve farm income with special focus on small farmers.
- To optimise utilization of water resources with potential for aquaculture.
- To suggest measures for improving marketing conditions for freshwater fish.

Mandate. The fisheries unit at NARC is to conduct research in the areas of national importance and to bridge the gap in knowledge limiting expansion of fish farming through production-oriented adaptive research. Research will also be conducted in selected areas of freshwater aquaculture where provincial research is nonexistent or seriously inadequate. Further strengthening of linkages with national and international institution and on campus collaboration with other unit is emphasized.

Current programme. The current research programme emphasizes two areas: the selection, controlled breeding, and fingerling rearing of catla catla and studies on cage culture and fish stock assessment in Rawal Lake.

Proposed programme

Priority 1

- Studies on reservoir fisheries and feasibility studies on cage and pen culture.
- Artificial propagation of carps and studies on genetic improvements of major carps for higher yield.
- Studies on optimizing natural food productivity using fertilizers and formulation of supplementary feeds for semi-intensive fish farming level.

- Culture techniques of fresh water prawns in ponds.
- Studies on fish marketing.

Priority 2

- Studies on commonly occurring fish diseases.

Priority 3

- Breeding biology and growth performance of indigenous catfish and carps with aquaculture potential.
- Study on aquaculture economics under various managemental inputs.

Linkages and relationships. On campus, the fisheries unit will require participation from animal nutrition, animal health, farm mechanization, and agricultural economics. The fisheries unit at NARC will be an active member of the national coordinated programme and will conduct agreed upon tests regarding fisheries in the climatic zones of Islamabad. Collaboration with other Pakistani centres will occur where site-specific fisheries research is in progress. This will be normally through the farming systems research projects. Linkages will be developed with international agencies such as ICLARM, NACA, FAO, CIFRI, NIFI for the exchange of literature and information.

Expected accomplishments

- Fish production from reservoirs is envisaged to be increased from the present 40 to 45 kg/ha to 130 to 150 kg/ha.
- The development of propagation techniques for major carps and genetic improvement will ensure fish seed supply for the aquaculture system and make strains with optimum growth potential available.
- Marketing studies will help new fish farmers to enter the business and help existing fish farmers to get maximum returns from their investments.

RESOURCE REQUIREMENTS: ANIMAL SCIENCES

[redacted]

ANIMAL BREEDING AND GENETICS: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Performance evaluation of the herds of Jersey cattle and Nili-Ravi buffaloes maintained at ASI	1	1.0	3111	1.0	11130	1.0	12049	0.5	12315	0.5	10885	0.5	12458
2. Production of superior cattle/buffalo germplasm through selective breeding.	1	1.0	40000	1.0	40000	1.0	55000	1.0	62000	0.5	75000	0.5	90000
3. Upgrading of native cattle in Islamabad district through crossing with Jersey semen.	1	1.0	60000	1.0	100000	0.5	120000	1.0	150000	1.0	175000	0.5	270000
4. Studies on genetic and non-genetic factors affecting fertility in cattle/buffalo.	2	-	-	-	-	0.5	11000	-	-	-	-	0.5	10000
5. Studies on genotype environmental interaction.	2	-	-	-	-	-	-	0.5	13000	-	-	0.5	10000
6. Studies on pre-weaning and post-weaning growth parameters in cattle/buffalo calves.	3	-	-	-	-	-	-	-	-	1.0	10000	0.5	10000
Total		3.0	103111	3.0	151130	3.0	198049	3.0	237315	3.0	270885	3.0	402458

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	271272	279410	287792	296426	455838	667392
	Additional	0	0	9280	35649	33007	42470
	Operational Funds	103111	151130	198049	237315	270885	402458
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	374383	430540	495122	569390	759730	1112320

* Number of scientists (BP 17-20) 1 SSO, 2 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

REPRODUCTIVE PHYSIOLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Factors affecting post partum reproductive performance in buffaloes.	1	1.0	60000	1.0	90000	1.0	100000	2.0	110000	2.0	120000	2.0	155000
2. To find effective ways to diagnose pregnancy at an early stage and to detect oestrus in silent buffaloes.	1	1.0	40000	1.0	80000	1.0	50000	1.0	60000	1.0	60000	1.0	90000
3. Endocrinological studies in buffalo bulls with special reference to hastening puberty.	2	1.0	40000	1.0	40000	1.0	20000	1.0	20000	1.0	50000	1.0	110000
4. Studies on biochemical aspects of buffalo semen and to develop appropriate extender for its preservation.	2	1.0	12000	1.0	18495	1.0	122889	1.0	160000	1.0	100000	1.0	150000
5. Pubertal development in buffalo heifers with reference to nutrition, management, and endocrinological aspects.	3	-	-	-	-	-	-	1.0	24637	1.0	97959	1.0	130825
6. Identification of causes of poor quality semen in cross-bred bulls.	3	1.0	10000	1.0	10000	1.0	20000	-	-	-	-	-	-
Total		5.0	162000	5.0	238495	5.0	312889	6.0	374637	6.0	427959	6.0	635825

BUDGET						
Staff Costs: Existing (1988/89 + 3%/year)	428832	441697	454948	468596	720158	1054383
Additional	0	0	14384	56320	52146	67097
Operational Funds	162639	238495	312889	374637	427959	635825
Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	591471	680192	782220	899553	1200263	1757305

* Number of scientists (8P 17-20) 1 SSO, 4 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

EMBRYO TRANSFER: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Superovulatory and endocrine responses in local cattle and buffaloes with PMSG and FSH.	1	2.0	100000	2.0	200000	2.0	225000	1.0	200000	1.0	125000	1.0	200000
2. Study of factors affecting superovulation response and embryo recovery in buffaloes.	1	1.0	57324	1.0	30634	1.0	77370	1.0	50000	1.0	75000	1.0	89450
3. Microsurgery of cattle and buffalo embryos.	2	-	-	-	-	-	-	1.0	112209	1.0	100000	1.0	175000
4. In-vitro culture and sexing of embryos.	3	-	-	-	-	-	-	-	-	1.0	113573	1.0	150000
Total		3.0	157324	3.0	230634	3.0	302370	3.0	362209	4.0	413573	4.0	614450

BUDGET							
	Staff Costs: Existing (1988/89 + 3%/year)	414264	426692	439493	452677	695949	1018939
	Additional	0	0	14062	54427	50393	64842
	Operational Funds	157324	230634	302370	362209	413573	614450
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	571588	657326	755925	869314	1159915	1698231

*Number of Scientists (BP 17-20) 1 SSO, 4 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

MEAT PRODUCTION: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Studies on meat production capability of local sheep breeds.	1	1.00	32000	1.00	34000	1.00	38000	0.25	30000	0.50	40000	0.50	70000
2. Development of feedlot systems for economical beef and mutton production of buffalo calves.	1	1.00	50914	1.00	87419	0.50	90000	0.75	60000	1.00	50000	1.00	30000
3. Studies to determine economical age weight relationship for meat production of small and large ruminants.	1	-	-	-	-	0.50	30780	0.50	40000	1.00	60000	0.50	50058
4. Characterization and standardization of physical, bacteriological and chemical properties during handling, preservation (facking) and development of caracass grading system.	2	-	-	-	-	-	-	0.50	60531	0.50	67174	0.50	20600
5. Studies on the available amount of efficient utilisation of slaughterhouse by-products and waste.	3	-	-	-	-	-	-	-	-	-	-	0.50	152000
Total		2.0	82914	2.0	121419	2.0	158780	2.0	190531	3.0	217174	3.0	322658

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	217236	223753	230466	237380	365454	535061
	Additional	0	0	7703	28580	26462	34049
	Operational Funds	82914	121419	158780	190531	217174	322658
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	300150	345173	396948	456491	609090	891768

* Number of scientists (BP 17-20) 1 PSO, 1 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

DAIRY TECHNOLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. To develop a technology for the preservation of milk and preparation of milk products at farm level.	1	1.0	40000	1.0	65500	1.0	56000	1.0	142295	1.0	56161	2.0	215000
2. Study the microbiological aspects of dairy products in reference to public health.	1	1.0	65237	1.0	88778	1.0	65271	-	-	-	-	-	-
3. Development of starter culture production and propagation technique for the improvement of indigenous fermented milk products.	2	-	-	-	-	1.0	81000	1.0	50000	1.0	130000	1.0	96038
4. Use of different enzymes for appropriate utilisation of various milk components.	2	-	-	-	-	-	-	2.0	50000	2.0	90500	1.0	100000
Total		2.0	105237	2.0	154278	3.0	202271	4.0	242295	4.0	276661	4.0	411038

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	277128	285442	294005	302825	465556	681621
	Additional	0	0	9402	36409	33710	43376
	Operational Funds	105237	154278	202271	242295	276661	411038
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	382365	439720	505678	581529	775927	1136035

* Number of Scientists (BP 17-20) 2 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

POULTRY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Performance testing of various commercial broiler strains of poultry in Pakistan.	1	2.0	286000	2.0	361294	1.5	340000	1.5	400000	2.0	250000	1.5	300000
2. Study of meat quality of various poultry strains/breeds.	1	-	-	-	-	-	-	-	-	-	-	-	-
3. Study on various managemental aspects of poultry	1	-	-	-	-	0.5	62821	0.5	97612	-	-	0.5	97642
4. Performance testingt of various layer strains of poultry in Pakistan.	2	-	-	-	-	-	-	-	-	1.0	152260	1.0	200000
Total		2.0	286000	2.0	361294	2.0	402821	2.0	497612	3.0	402260	3.0	597642

BUDGET							
	Staff Costs: Existing (1988 + 3%/year)	269952	278051	286392	294984	676911	991065
	Additional	0	105556	46033	52938	49014	63068
	Operational Funds	286000	361294	402821	497612	402260	597642
	Total (1988 + 15%/year)	555952	639345	735247	845533	1128185	1651775

* Number of scientists (BP 17-20) 2 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

ANIMAL NUTRITION: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Development, identification and adaptability of suitable technologies to enhance the nutritional value of agricultural wastes and industrial by-products for production of complete least cost formula rations.	1	2.0	100000	2.0	110000	2.0	110000	1.0	100000	1.0	100000	1.0	135000
2. Development of suitable technologies to produce solidified multinutrient urea molasses blocks, briquette, pellets, liquid supplements etc., on least cost principle for diverse ecological farming systems and verification of these products in feeding trials.	1	2.0	80000	2.0	100000	1.0	80000	1.0	80000	1.0	80000	1.0	120000
3. Research on the use of various additives to increase the nutritional value of silage.	1	1.0	50000	1.0	50000	1.0	60000	1.0	60000	1.0	60000	1.0	110000
4. Digestibility and nitrogen balance trials on sheep for the evaluation of nutritive value of various types of green fodder, hay and silage.	1	1.0	90000	1.0	100000	1.0	110000	1.0	110000	1.0	100000	1.0	135000
5. Development of efficient and economical processing methods for the utilization of poultry litter and animal wastes in livestock feeding.	2	-	-	1.0	50000	1.0	60000	1.0	70000	1.0	80000	1.0	120000
6. To establish the nutrient requirements of various classes of livestock.	2	-	-	1.0	60000	1.0	90000	1.0	90000	1.0	90000	1.0	130000
7. Evaluation of conventional protein and energy supplements for livestock feeding.	2	-	-	1.0	39388	1.0	51425	1.0	70000	1.0	70000	1.0	100000
8. Studies on the change in quality and nutrients availability during processing and storage of feed stuffs and compound feeds.	2	-	-	-	-	1.0	80000	1.0	80000	1.0	90000	1.0	130000
9. Studies on mineral metabolism in lactating animals	2	-	-	-	-	1.0	90000	1.0	90000	1.0	80000	1.0	120000

continued

ANIMAL NUTRITION (continued)

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
10. Evaluate feed lot systems for mutton and beef production based on complete least cost rations.	2	-	-	-	-	-	-	1.0	90000	1.0	70000	1.0	100000
11. Manipulation of rumen ecosystem for maximum utilization of feed resources in livestock production.	3	-	-	-	-	-	-	1.0	71450	1.0	85000	1.0	120000
12. Comparative estimation of feeds for by-pass protein (Rumen under graded protein) with in-vivo and in-vitro techniques.	3	-	-	-	-	-	-	-	-	1.0	55000	1.0	90000
13. Studies on the economical formulation and efficient utilization of milk replacers and early weaning diets.	3	-	-	-	-	-	-	-	-	1.0	62000	1.0	100000
14. Standardization of various analytical techniques for the routine analysis of feedstuffs.	3	-	-	-	-	-	-	-	-	1.0	62048	1.0	100583
Total		6.0	320000	9.0	509388	10.0	731425	11.0	911450	14.0	1084048	14.0	1610583

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	1178232	1213579	1249986	1287486	1824203	2670816
	Additional	0	0	0	79688	132088	169961
	Operational Funds	320000	509388	731425	911450	1084048	1610583
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	1498232	1722967	1981412	2278624	3040339	4451360

* Number of scientists (BP 17-20) 2 SSO, 8 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

ANIMAL HEALTH: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Improvement of haemorrhagic septicaemia vaccine.	1	1.0	150000	1.0	200000	1.0	150000	1.0	150000	0.5	100000	-	-
2. Development of a combined vaccine for haemorrhagic septicaemia and foot and mouth disease.	1	1.0	100000	1.0	150000	1.0	200000	1.0	300000	1.5	150000	-	-
3. Identification of types and sub-types of animal viruses.	1	-	-	-	-	1.0	100000	1.0	150000	1.0	150000	2.0	250000
4. Assessment of economic losses due to animal diseass.	1	-	-	-	-	-	-	-	-	-	-	-	-
5. Development of prophylactic measures against haemoprotozoan, ecto and endo parasites.	1	1.0	30000	1.0	50000	1.0	50000	1.0	50000	1.0	100000	2.0	150000
6. Pathogenesis of haemorrhagic septicaemia in cattle and buffaloes.	1	1.0	75000	1.0	100000	1.0	50000	1.0	25000	-	-	-	-
7. Diagnosis, pathogenesis and control of newly emerging diseases.	1	1.0	75000	1.0	100000	1.0	150000	1.0	150000	1.0	150000	2.0	250000
8. Control of mastitis in cattle and buffaloes.	2	-	-	-	-	-	-	-	-	1.0	50000	1.0	75000
9. Development of diagnostic tests for mycoplasmosis and improvement of caprine pleuro-pneumonia vaccine.	2	-	-	-	-	-	-	-	-	1.0	100000	2.0	200000
10. Pathogenesis of haemoprotozoan diseases of cattle and buffaloes.	2	-	-	-	-	-	-	-	-	1.0	50000	1.0	100000
11. Development of monoclonal antibodies against animal pathogens.	2	-	-	-	-	-	-	1.0	70000	1.0	100000	1.0	250000
12. Pakistan culture collection program.	3	-	-	-	-	-	-	1.0	15000	1.0	23000	1.0	150000
13. Immunology of the buffalo.	3	1.0	21775	1.0	33000	1.0	41000	1.0	45000	1.0	40000	1.0	75000
Total		6.0	451775	6.0	633000	7.0	741000	9.0	955000	11.0	1013000	13.0	1500000

BUDGET							
	Staff Costs: Existing (1988/89 + 3%/year)	949608	978096	1007439	1037662	1706283	2498169
	Additional	0	0	104558	133440	123549	158974
	Operational Funds	451775	633494	741332	96[illegible]26	1013973	1506472
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	1401383	1611590	1853329	2131328	2843805	4163615

* Number of scientists (BP 17-20) 1 CSO, 1 PSO, 8 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SHEEP AND WOOL: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Production potential appraisal of various breeds of sheep.	1	0.5	35000	0.5	50500	0.5	50000	0.5	68000	0.5	78000	0.5	108000
2. Improving the productivity of sheep through cross-breeding and selection.	1	0.5	25000	0.5	30400	0.5	50000	0.5	54000	0.5	64000	0.5	84000
3. Genetic and non-genetic factors affecting the fertility and prolificacy of sheep.	1	0.5	17000	0.5	35000	0.5	50000	0.5	56000	0.5	64000	0.5	104000
4. Maximization of productivity in sheep through improved management systems.	1	0.75	30000	0.75	35000	0.75	45000	0.75	60000	0.75	70000	0.75	125000
5. Studies of the improvement of fleece characteristics.	2	0.25	15000	0.25	20345	0.25	30000	0.25	38000	0.25	40000	0.25	55000
6. Study of physiological aspects of adaptability in exotic and local animals.	2	0.5	15000	0.5	30000	0.5	30096	0.5	40544	0.5	46591	0.5	62708
Total		3.0	137000	3.0	201245	3.0	265096	3.0	316544	3.0	362591	3.0	538708

BUDGET								
Staff Costs: Existing (1988/89 + 3%/year)	364128	375052	386303	397892	610159	893333
Additional	0	0	11342	47717	44181	56848
Operational Funds	137000	201245	265096	316544	362591	538708
Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	501128	576297	662742	762153	1016931	1488889

*Number of scientists (BP 17-20) 1 PSO, 2 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

GOAT PRODUCTION: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Genetic appraisal of various breed of goats in Pakistan.	1	0.5	230000	1.0	292950	0.5	163760	0.5	203418	0.5	135182	0.5	200845
2. Improving the productivity of goats through crossbreeding and selection.	1	0.5	230000	1.0	292950	0.5	163761	0.5	203416	0.5	135184	0.5	200844
3. Genetic and non-genetic factors affecting fertility and prolificacy of goats.	2	-	-	-	-	0.5	163761	0.5	203416	0.5	135184	0.5	200844
4. Effect of feeding and grazing regimens on mutton and milk production in goats.	1	-	-	-	-	0.5	163761	0.5	203416	0.5	135184	0.5	200844
5. Maximization of productivity in goats through improved management, housing and health coverage.	2	-	-	-	-	-	-	-	-	1.0	135184	1.0	200344
Total		1.0	460000	2.0	585900	2.0	655043	2.0	813666	3.0	675918	3.0	1004221

BUDGET						
	Staff Costs: Existing (1988/89 + 3%/year)	474168	488393	503045	518136	1137416	1665290
	Additional	0	156183	77349	88951	82359	105973
	Operational Funds	460000	585900	655043	813666	675918	1004221
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	934168	1074293	1235437	1420753	1895693	2775484

* Number of Scientists (BP 17-20) 1 PSO,. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

FISHERIES: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Studies on reservoir fisheries and feasibility studies on cage/pen culture.	1	4.0	131000	3.0	143460	3.0	172630	3.0	219300	3.0	225000	3.0	250000
2. Artificial propagation of carps and studies on genetic improvements of major carps for higher yields.	1	3.0	175000	2.0	183490	2.0	192320	2.0	244400	2.0	250000	2.0	350000
3. Studies on optimizing natural food productivity using fertilizers and formulation of supplementary feeds of semi-intensive fish farming level.	1	-	-	1.0	56558	2.0	88628	2.0	112463	2.0	114997	1.0	150009
4. Culture techniques of fresh water prawns in ponds.	1	-	-	1.0	50000	2.0	68050	2.0	86500	2.0	90000	1.0	138300
5. Studies on commonly occuring fish diseases.	2	-	-	-	-	-	-	-	-	1.0	20000	1.0	50000
6. Studies on fish marketing system.	2	-	-	-	-	-	-	-	-	1.0	13470	1.0	50000
7. Breeding biology and growth performance of indigenous cat-fish and carps with aquaculture potential.	3	-	-	-	-	-	-	-	-	-	-	1.0	50000
8. Study on aquaculture economics under various managemental inputs.	3	-	-	-	-	-	-	-	-	-	-	1.0	21700
Total		7.0	306000	7.0	433508	9.0	521628	9.0	662663	11.0	713467	11.0	1060009

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	680064	700466	721480	743124	1200603	1757802
	Additional	0	0	60962	93893	86934	111860
	Operational Funds	306000	433508	521628	662663	713467	1060009
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	986064	1133974	1304070	1499680	2001004	2929671

* Number of Scientists (BP 17-20) 1 PSO, 2 SSO, 5 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

NATURAL RESOURCES

Soil Sciences

Pakistan has 22.8 million hectares under cultivation. Out of this, 16.6 million hectares are irrigated; the rest depend exclusively on rainfall. A large share of the agricultural land is affected by excess salts. Of the salt-affected land, 1.2 million hectares are under cultivation, whereas 4.5 million hectares are in the severe grip of salinity or sodicity and hence unsuitable for cultivation. In addition 2.1 million hectares are waterlogged, and 0.4 million hectares are badly eroded by water and wind action.

The soils of Pakistan have been used for crop production for centuries without proper management. The soils are depleted in one or more nutrients due to continuous cropping. Intensive cultivation to meet the food and fibre needs of a growing population will further deplete the soils. This will result in nutrient imbalances. Continued mismanagement of the soils will aggravate the situation.

The major production problems are:

- Decline in soil productivity due to salinity, sodicity and waterlogging.
- Reduced soil fertility associated with low organic matter and intensive and exhaustive cropping.
- Improper fertilizer management resulting in inefficient plant nutrient uptake and reduced yields.
- Ineffective biological nitrogen fixation in most agro-ecological zones.
- Poor soil tilth, reduced infiltration, and low crop water-use efficiency.
- Accelerated water and wind erosion caused by inadequate conservation practices.
- Environmental degradation associated with soil-related agricultural and industrial chemical effluents.

Goals and objectives. The principal aims of the soil fertility and plant nutrition programme are:

- To develop scientific criteria for site-specific fertilizer recommendations for field crops and benchmark soils.
- To develop and gather information for the management of soil fertility in barani areas.
- To assess and improve soil fertility technology for selected agronomic and horticultural crops.
- To provide soil advisory service to NARC research programmes, other agricultural institutions, and farmers.
- To evaluate micronutrient (Zn, B, and Fe) nutrition of selected crops and develop management practices.
- To assess the validity and reliability of the use of soil families in transfer of soil management recommendations.

The principal aims of the flooded rice soils programme are:

- To ameliorate plant nutrient deficiencies.
- To refine soil analytical procedures and techniques for more valid and reliable soil test results and fertilizer recommendations for rice.
- To improve fertilizer use efficiency.

In soil chemistry and mineralogy, the principal aims are:

- To identify and quantify the soil components (layer silicates) in agriculturally important soils of Pakistan.
- To study nutrient dynamics in soils in relation to their clay mineral composition.

- To study reactions in soil and at the soil-root interface to better understand the fate of soil amendments.

The principal aims in the stress physiology programme are:

- To determine basic physiological processes of plants impacted by stress (salinity, drought, and temperature).
- To develop genetic screening techniques based on physiological and chemical processes of the selected plants (biochemical markers).

In soil physics, the principal aims are:

- To develop trained personnel and research facilities for soil physics research.
- To study soil-water-plant relationships under drought and salt stress.
- To study the dynamics of soil physical properties in relation to tillage techniques.

The principal aims of the soil biology programme are:

- To study life strategies of economic organisms which could improve soil productivity.
- To develop artificial microbial inoculants (bio-fertilizers) of nitrogen-fixing and phosphorus-mobilizing organisms and application techniques for selected ecologies.

Mandate. This section of NARC has the mandate to support the commodity research programmes at NARC as well as the national commodity programmes, to initiate soils research in neglected areas, to strengthen existing soils research in the country, and to arrange training programmes for provincial research and extension workers.

Advanced research. Advanced research involves molecular levels of stress tolerance in selected crop plants, use of radioisotopes and labelled material for various research studies, development and production of N+P biofertilizers, and controlled environment research for higher agricultural productivity.

Current programme. The soil fertility and plant nutrition programme includes studies to improve analytical and soil test procedures, new fertilizer technology, micronutrient mapping, and development of methods for organic composting to effect changes in soil properties. The management of flooded rice soils programme is involved with development of improved fertility and assessment and management for certain nutrients including N, P, and Zn in collaboration with IRRI. The soil chemistry and mineralogy programme studies clay identification, micronutrient fixation and absorption and availability in different soils. The stress physiology programme investigates biochemical properties as affected by salt stress and amelioration by plant nutrients. The biological nitrogen fixation programme does studies on legume rhizobium and *Azolla anabaena* symbiosis, including microbial diagnostic techniques, isolation, characterization, and selection of suitable rhizobium strains; development of low cost azolla nursery management techniques; interspecies interactions; and carrier materials for artificial inoculants (biofertilizers).

Proposed programme: Soil Fertility and Plant Nutrition

Priority 1

- Evaluation of chemical indices for predicting nitrogen fertilizer requirements of crops.
- Soil test calibration for determining phosphorus requirements of arable crops.
- Development of methodology for site specific fertilizer recommendations.
- Diagnosis and amelioration of nutritional problems in fruit crops.
- Diagnosis and correction of micronutrient disorders in crops.

Priority 2

- Quantification of N losses under different ecosystems.
- Management of fertility of salt-affected soil used for rice-based cropping.

Proposed programme: Soil Chemistry and Mineralogy

Priority 1

- Chemical and mineralogical studies on agricultural soils with implications for N, P and K fertilizer use.
- Tracer studies on interactive effects of organic matter and soil mineralogical composition on crop nutrition.
- Management of sulphur nutrition in soils under various crops with particular emphasis on oilseeds.
- Use of industrial and municipal wastes for crop production and environmental pollution.

Proposed programme: Soil Physics, Micromorphology, and Pedology

Priority 1

- Development of improved soil management practices alleviating physical soil properties affecting productivity.
- Root behaviour of principal crops in relation to soil physical conditions.
- Moisture and solution movement in major soils of Pakistan in relation to crop production.
- Aggregate stability for predicting/controlling soil loss.

Proposed programme: Soil Biology

Priority 1

- Symbiotic biological nitrogen fixation (Legume inoculants).
- Non associative nitrogen fixation crop residue utilization for nitrogen fixation—fungal/bacterial or bacterial/ bacterial consortium.
- Phosphorus-mobilizing non-associative fungi (hyphomycetes).

Priority 2

- Biological inhibitors for reduced soil nitrogen efflux.
- Sexual propagation techniques in *Azolla* spp.
- Collection and maintenance of economic organisms.

Priority 3

- Biological disinfestation of problem soils (root/wilt diseases).

Proposed Programme: Stress Physiology

Priority 1

- Influence of environmental stresses on reproductive physiology of crop plants (collaborative research project between Pakistan and UK).
- Photosynthetic efficiency, source/sink relationship, grain filling under salt, drought, and temperature stress.
- Hormone dynamics under salt, drought, and temperature stresses in wheat and rice.
- Establishment of bio-chemical markers.
- Molecular level of stress tolerance.
- Cultivation of non-conventional salt tolerant plants on problem soils (international collaborative research project between Pakistan and Netherlands).
- Agro-industrial potential of non-conventional crops, on marginal lands.
- Examine nutritional characteristics of tolerant plants for human and animal consumption.
- Field trials, economics of selected stress tolerant plants for useful products.

Linkages and relationships. On campus, soil science collaborates with all commodity programmes at NARC and Farm Machinery Institute. Soil science also has collaborative relations with Sugar Crops Research Institute, Mardan, NWFP; Barani Agricultural Research Institute, Chakwal; provincial agricultural research institutes (Faisalabad, Peshawar, Tandojam, Quetta), and rice research institutes (Kala Shah Kaku and Dhokri). Other Pakistani centres that collaborate with soil science are agricultural universities (Faisalabad, Peshawar, Sind); atomic energy centres (Faisalabad, Tandojam, Peshawar); Karachi, Punjab, and Quaid-i-Azam universities; Pakistan Tobacco Board; Soil Survey of Pakistan; PCRWR; ISWRI; Mona Project; Water and Power Development Authority; National Fertilizer Development Corporation; Pakistan Forest Research Institute; and Azad Kashmir University. International linkages are established with ICARDA, IRRI, IITA, CIAT, ICRISAT, IFDC, TSI, IPI, PPI, RIKEN, CSIRO, and the following universities: Hawaii, Sussex, Bangor, Free, Kyoto, Justis Liebig, Kyushu, Texas A & M, Idaho, Utah, Iowa, Cornell, Missouri, California (Riverside), and Waite Agricultural Institute.

Expected accomplishments

- Scientific criteria for making site-specific fertilizer recommendations for major agricultural crops and fruit trees will be developed.
- A major saving in fertilizer investment will be achieved by improved fertilizer use efficiency.
- Improved crop production will result from amelioration of plant nutrient problems.
- Development of a package of legume rhizobium technology for selected crops (pulses, fodder and forage, and soybean) suitable for different ecologies along with Azolla spore propagation techniques will give expected savings of Rs. 0.7 billion in nitrogen fertilizer use.
- Biofertilizers (P and N source) will be formulated using predominantly soil hyphomycetes capable of P solubilization and permitting cross feeding to non-associative nitrogen-fixing bacteria (Bacterial/fungal consortium).
- Information on mineralogical composition of major agricultural soils will help manage plant nutrient supply from soils on a sustained basis.
- Soil physics research will assist in efficient use of nutrients and water in marginal soils and climatic conditions.
- Salt-affected and arid lands will be utilised by growing selected genotypes tolerant at molecular levels to get useful products of economic value.
- Major physiological characters responsible for higher yield (photosynthetic efficiency and grain filling) in tolerant cultivars will be used by Pakistani breeders for improvement of selected agricultural crops.
- Biochemical markers identified for stress tolerance will be used for rapid screening of germplasm of selected crops.

Water Resources

The water resources section at NARC is engaged in research related to soil and water conservation for barani lands and watersheds, irrigation systems and management, and agricultural meteorology. The major production problems are:

- Fluctuations in water availability for agricultural production due to uncertain river flows and erratic rainfall distribution.
- Shortage of surface irrigation water during winter due to minimal surface storage reservoirs.

- Water delivery losses in irrigation systems associated with poorly managed earthen water channels.
- Waterlogging and salinity associated with inefficient irrigation system in the Indus basin.
- Poor quality ground water, which restricts the expansion of cultivated area.
- Poor drainage facilities due to minimal gradient and absence of disposal systems.
- Inadequate irrigation application and low water use efficiency at the farm level caused by unleveled fields and non-scheduled irrigation.
- Water and wind erosion due to inadequate soil and water conservation practices.
- Siltation problems in water reservoirs, rivers, and irrigation channels due to watershed degradation.
- Inefficient barani water conservation and management caused by inefficient land forming techniques and tillage practices.
- Lack of weather information and interpretation for farmer use.

SOIL AND WATER CONSERVATION FOR BARANI LANDS AND WATERSHEDS

In the barani lands and watersheds, people live close to the subsistence level because agricultural production depends mainly on the occurrence, distribution, and utilization of rainfall. Soil erosion through water or wind and destruction of vegetation in watersheds are occurring rapidly. Nineteen million hectares are affected by water and wind erosion, which is about 55% of the total area suitable for agriculture and forestry. This includes 2.2 million hectares of sailaba, 5.4 million hectares of barani, 8.6 million hectares of rangelands, and 3.2 million hectares of forest area. Improved soil and water conservation practices are needed for barani and watershed areas to control erosion and loss of rain water through runoff for increased agricultural production on a sustainable basis. The programme activities initially will be restricted to the control of water erosion for increased agricultural production in the Pothwar area due to limited financial and staff resources.

Goals and objectives. The principal aims are to develop, adapt, and demonstrate integrated land-use techniques using a sub-watershed/catchment approach in order to raise the productivity and improve management of resources (land, water, vegetation, etc.) for barani lands.

Mandate. As part of the water resources research section at NARC, the soil and water conservation programme is to conduct interdisciplinary research using a systems approach to increase agricultural production through improved soil and water conservation techniques. This approach requires integration of engineering, plant science, water science, and soil physics.

Current programme. Research thrusts include: a) development of database and knowledge related to runoff-sediment load, b) rainfall-runoff relationships, c) water storage for supplemental irrigation, d) conservation structures for erosion control, e) integrated land use, f) land forming and moisture conservation, g) drainage of access water, h) soil-water-plant relationships and i) hydro-meteorology.

During 1988-89, the three on-going research projects were organized under a research programme entitled "Soil and water conservation". Studies have been designed for each sub-watershed. The on-going activities in this programme are measurement of runoff and sediment load, integrated land use (crops, forest and fruit plants, and pastures), supplemental irrigation for fruit plants, storage of surface runoff in earthen reservoirs and its conservation by reducing seepage, gully reclamation practices, monitoring of soil moisture and utilization by plants, water-harvesting techniques, and moisture conservation practices.

Proposed programme. The proposed programme assesses productive research opportunities by introducing high value crops, multipurpose forest plants, fruit plants, and irrigation innovations

into the farming systems of barani area. The other areas include conservation tillage and soil-water-plant relationships for few selected crops, fruit plants and vegetables suitable for barani areas under annual rainfall of 750 mm or more.

Priority 1

- Development of a soil and water conservation database covering soil, water, vegetation, and climatic research done in Pakistan or elsewhere.
- Simulation of rainfall-runoff-soil loss functions and validations using data collected at research sites.
- Simulation of resource management strategies and validations using land use data collected at research sites.

Priority 2

- Conservation tillage and development of a tillage index for barani areas.
- Development of soil-water-plant relationships for selected plants related to barani conditions.

Advanced research. Advanced research using computer and mathematical modelling and simulations will be introduced into soil and water conservation research related to identified research thrusts.

Linkages and relationships. On campus, the participation from Barani agricultural research and development, farming systems research, land resources, farm machinery institute, RMF, horticulture, forage, and social sciences is required. Collaboration with Barani Agricultural Research Institute, Chakwal; Barani Agriculture College, Rawalpindi; NWFP Agriculture University, Peshawar; and NWFP Engineering University, Peshawar, will be developed. In addition, the soil and water conservation programme will collaborate actively with Water and Power Development Authority, Pakistan Council for Research in Water Resources, AZRI, and Pakistan Forest Institute in activities related to this programme. Relationships will be developed with international bodies such as ICRISAT, SCS-USDA, AERC-CSU, and FAO. The transfer of packages of technology developed under this programme will require different forms depending upon the clients. Validation of technology will require the participation of farming systems research, technology transfer unit, Agency for Barani Agriculture Development, Water and Power Development Authority, and provincial soil and water conservation departments.

Expected accomplishments

- A package of technology related to integrated land and water use by barani lands and watersheds, which can be used by development and extension agencies will be developed. Emphasis will be placed on the transfer of already developed technology at Fatehjang sub-watershed for farmer implementation. The first package will be ready for implementation in 1990.
- A simplified package that can be adopted by farmers at three investment levels (high, medium, and low) in barani areas with an average annual rainfall of 750 mm or more will be developed. The first package will be ready for implementation in 1992.
- The results related to tillage index and soil-water-plant relationships for selected crops will provide information for the development of appropriate farming systems in barani areas. The initial results will be available for use and technology transfer in 1994.

IRRIGATION SYSTEMS AND MANAGEMENT

The twin menace of waterlogging and salinity is a consequence of the poor management of the world's largest contiguous irrigation system. The overall irrigation efficiency is about 34%. In

the Indus basin, more efficient water use is vital. The on-going development activities related to the Command Water Management Project need to be strengthened by improving water use efficiency at the farm level where most of the losses occur. Better irrigation management is also needed in the Indus basin to overcome the problem of waterlogging and salinity. At present, little information is available to improve water use and application at the farm level for increased crop production and productivity per unit of water used.

For barani areas, the introduction of small-scale irrigation techniques and water management practices is needed to ensure successful crop harvests and cultivation of high value crops. The cultivation of vegetable and fruits in barani areas will ultimately increase net farm return. The improvement of water-use efficiency at the farm level and development of innovative irrigation techniques suitable for barani areas will be emphasized.

Goals and objectives. The principal aims are:

- To develop, test, and adapt specialised and innovative irrigation techniques for varying soils, climate, land use, farm size, and socio-economic considerations related to barani areas (including the development of improved management and operational procedures for these techniques).
- To develop improved management procedures for surface irrigation to optimise crop production and reduce drainage surplus at the farm level.

Mandate. As part of the water resources research section, the irrigation systems and management programme is to conduct interdisciplinary research using a systems approach to increase the productivity of per unit of water used. The interdisciplinary approach requires integration of engineering, water science, plant science, and soil physics.

Current programme. The on-going research projects include: water measurement and control systems development and development of high efficiency and low-cost irrigation system using locally available materials. The scientific studies include development of low-cost, high efficiency irrigation systems, evaluation of performance parameters related to irrigation application for sprinkler and trickle irrigation, evaluation of benefits of supplemental irrigation using portable raingun sprinklers in barani areas, evaluation of surface irrigation methods (basin, border, furrow, and broadbed), and evaluation of various water-measuring devices suitable for Pakistani conditions.

Proposed programme. The basic concepts of sprinkler and trickle irrigations will be used to develop low-cost innovative techniques suitable for barani areas. The development of improved surface irrigation procedures to optimise crop production at the farm level includes water use and application efficiency, design, and layout of farm water delivery systems and irrigation scheduling. The other areas include the development of soil-water-plant relationships for wheat, soybeans, and maize crops under supplemental irrigation. The proposed research activities will be confined to thrusts related to NARC mandate. However, the results may be applicable to other areas of the country. The proposed research activities are:

Priority 1

- Improving water use and application efficiency at farm level for barani areas with supplemental irrigation (including sprinkler and trickle irrigation).
- Design and layout of improved water delivery systems at the farm level for barani areas with supplemental irrigation (including water application and control devices like siphons, etc.)
- Computerized irrigation management strategies at farm level for barani areas with supplemental irrigation.

Priority 2

- Irrigation and energy scheduling at the farm level for barani areas with supplemental irrigation.
- Development of soil-water-plant relationships for wheat, soybeans, and maize under supplemental irrigation.

Advanced research. Advanced research using computer and mathematical modelling and simulations will be introduced into irrigation systems and management research related to identified research thrusts.

Linkages and relationships. On campus, the irrigation systems and management programme requires participation from Farm Machinery Institute, farming systems research, social sciences, and land resources. Collaboration with provincial research institutions includes the development of relationships with the On-farm Water Management Research and Training Project, University of Agriculture, Faisalabad, Sind Agriculture University, Tandojam; Agriculture Research Institute, Quetta; NWFP Engineering University, Peshawar; and Punjab Irrigation Research Institute, Lahore. The NARC irrigation systems and management programme will also serve as one of the collaborating units in a proposed coordinated research programme under irrigation systems management research.

Collaboration with Pakistan Council for Research in Water Resources, AZRI, and ARINA will be developed. A project proposal entitled "Improving Water Use and Application Efficiency at Farm Level" has been submitted to irrigation system management research consultants for funding by Ministry of Water and Power.

Collaboration with the following international institutions will be developed: International Irrigation Centre, Utah State University, USA; Colorado Institute of Irrigation Management, Colorado State University, USA; ISM-R University of Idaho Consultants, USAID; Irrigation Support Project for Asia and Near East, USAID; International Irrigation Management Institute, Lahore, Pakistan; Water Technology Centre, California State University, USA; USDA-ARS Soil and Water Research, AERC, Fort Collins, Colorado, USA.

For technology transfer, the collaboration and participation of the technology transfer unit, farming systems research, and provincial command water management projects is required. Asses. ment will be in terms of increased productivity per unit of water use, net farm return, and clients' acceptance. Linkage with private equipment companies and manufacturers related to irrigation will be developed.

Expected accomplishments

- Guidelines will be developed for the selection of suitable irrigation systems under given soil, climate, land use, farm size, and socio-economic considerations. The initial guidelines for extension purpose will be available in 1992.
- Manuals will be developed for efficient and effective utilisation of scarce water resources for increased crop production and to reduce drainage surplus for barani areas. These manuals will be available for use in 1996.
- An irrigation advisory service will be created for Islamabad capital territory area in collaboration with transfer of technology unit. This service will be in operation in 1998.
- Linkage with private irrigation equipment companies and local manufacturers will strengthen the introduction and availability of suitable irrigation systems (sprinkler and trickle) in Pakistan. This linkage will be initiated during 1990.

AGRICULTURAL METEOROLOGY

Because changes in occurrence and distribution of rainfall and fluctuations in humidity drastically affect crop yields, knowledge of agro-meteorology is much needed for development of

high yielding cultivars, management of natural resources, development of packages of technology, and transfer of technology to various agro-ecological zones. This information is also needed to delineate agro-ecological zones. Agro-meteorological information also provides a basis for computerized modelling of crop yield, evapotranspiration, irrigation scheduling, disease infestation, and resource management.

Goals and objectives. The principal aims are:

- To collect, analyse, and disseminate agro-meteorological data collected at NARC, Islamabad, to various scientists.
- To develop an agro-meteorological database.
- Initiate weather modelling for agricultural activities using the agro-meteorological database.
- Initiate micro-climatological and climatological research studies related to irrigated and barani farming systems.

Mandate. As part of the water resources research section, the agricultural meteorology programme is to conduct research using an interdisciplinary approach for various agricultural activities which are affected by weather.

Current programme. At present, activity is on a small scale. The on-going programme includes collection, analysis, and reporting of daily agro-meteorology data, and interpretation of agro-meteorology data for various agricultural activities related to the wheat and maize crops.

Proposed programme.

Priority 1

- Development of an agro-meteorology database in collaboration with Pakistan Meteorology Department and Water and Power Development Authority
- Climatological and micro-climatological studies for irrigated and rainfed farming systems.
- Prediction of evapotranspiration using climatic data.
- Drought and flood management for agriculture.
- Yield forecast simulations and validations using field data.
- Pest and disease infestation forecasts and validation using field data.

Advanced research. Advanced research using computer and mathematical modelling simulations will be introduced into agricultural meteorology research.

Linkages and relationships. On campus, active participation of the crop commodity programmes, pest management, cereal diseases research, and farming systems research group is required. Collaboration will be developed with department of agro-meteorology, University of Agriculture, Faisalabad. Other collaborators are Ayub Agriculture Research Institute, Faisalabad; Sind Agriculture University, Tandojam; NWFP Agriculture University, Peshawar; and Agriculture Research Institute, Quetta. Active collaboration with the Pakistan Meteorology Department and Water and Power Development Authority is desired especially for the development of the agro-meteorology database. The ODA has shown interest in a joint research activity on "micro-climatological and climatological modelling for agriculture". A project proposal has been submitted to ODA for funding. Linkages with FAO and WMO will be developed to strengthen the programme activities.

Expected accomplishments

- Suitable meteorological and climatological information will be developed for formulating recommendations for planners, researchers, extension agents and farmers.
- Agro-meteorological and micro-climatological information for the development of

high yielding cultivars, appropriate farming systems, etc., will be available to researchers.

- Advisory services will be provided to farmers in Islamabad capital territory area allowing them to select suitable farming systems and to perform various agricultural activities based on agro-meteorology data.

Ecology

Agricultural production depends on the ecological conditions of an area. Many changes in the ecological conditions of Pakistan have occurred over the past few years. These changes largely owe their existence to anthropogenic activities, both local and global. Sporadic efforts are made by universities and few other agencies to look into ecological issues but on localized scale.

The major problems are:

- Global changes in environment that affect the agro-ecological conditions in Pakistan.
- Deterioration of the natural and planted vegetation of northern areas of the country following the influx of Afghan refugees.
- Absence of information for assessing the agro-ecological potential of various areas for proper land use planning.

Goals and objectives. The principal aims of the ecology programme are:

- To keep researchers and planners informed on local and global changes that can affect ecological conditions of Pakistan for prompt and appropriate action.
- To evaluate the effects of anthropogenic activities on habitat conditions and to develop strategies for reclamation of ecologically disturbed areas.

Mandate. To acquire and maintain information on the local and global changes in ecological conditions and coordinate ecological research in the country.

Current programme. Assessment of agro-ecological potential of the Pothwar area is the principal current activity of the ecology programme.

Proposed programme

Priority 1

- Maintenance of up-to-date information on global changes that can affect the ecological conditions of Pakistan.

Priority 2

- Development of habitat reclamation strategies for the ecologically disturbed areas.

Linkages and relationships. At NARC the ecology programme will have close association with the land and water resources scientists, range and forestry group, plant genetics resources and plant introduction units, and the farming system research experts. Within the country, the ecology programme will work with all the universities in the country working on various aspects of ecology. Pakistan Forest Institute, Soil Survey of Pakistan, Pakistan Council of Research in Water Resources, Pakistan Meteorological Department, WAPDA, and SUPARCO. International linkages will include UNEP, WorldWatch Institute, California Institute of Technology, NASA, NOAA, USDA, and USDE.

Expected accomplishments

- Up-to-date information on the ecological conditions will allow timely and appropriate action by the researchers and planners.
- Research on the effects of anthropogenic activities will allow qualitative and quantitative assessment of the extent of remedial measures needed to reclaim the

ecologically disturbed area. This will reduce the deterioration of wildlife habitat and siltation of the dams linked with the affected watersheds. The general ecological condition of the areas will also improve.

Remote Sensing

Pakistan's diverse vegetation and climate, and the high degree of spatial heterogeniety inherent in the landscape, necessitate the use of remote sensing technology to survey and monitor crops and natural resources. Compared with conventional survey methods, remote sensing technology offers information on the area, condition, and productivity of crops and natural resources of an area with reasonable accuracy, at a low cost per unit area, and in a short time. The major problems affecting production are:

- Need for correlating remote sensing with costly conventional survey methods for the vast heterogeneous terrain of the country under a variety of natural and planted vegetation.
- Lack of an analytical facility for monitoring the condition of crops and natural resources on national scale for timely action.
- Lack of a national natural resource inventory.

Goals and objectives. The principal aims of the remote sensing programme are:

- To set up, within PARC, a remote sensing unit which is capable of digital analyses of satellite and airborne data, and construction of simulation models for crops and natural resources.
- To train a multidisciplinary team of scientists, capable of initiating remote sensing application programs in crops and natural resources.
- To demonstrate the application of remote sensing data in monitoring crops and natural resources.

Mandate. To provide up-to-date qualitative and quantitative information regarding the condition of crops and natural resources of the country to provincial users and government planners.

Current programme. The remote sensing unit is involved in land-use mapping using satellite imageries and aerial photographs. Construction of a canopy reflectance model of wheat is planned for various varieties at different stages of growth.

Proposed programme

Priority 1

- Establishment of a remote sensing unit at NARC.

Priority 2

- Compilation of a national natural resource inventory
- Development of an early warning system for stress in crops.

Priority 3

- Construction of a canopy reflectance model of the wheat crop.

Advanced research. Advanced research will consist of improving methodology for interpretation of satellite and airborne data.

Linkages and relationships. On campus, collaboration is planned with wheat program, land and water resources, Barani Agricultural Research and Development, farming systems research. The remote sensing unit will also collaborate with SUPARCO, Pakistan Meteorology Department, Survey of Pakistan, and Pakistan Air Force. Internationally, collaboration is envisaged with Environmental Research Institute, Michigan, USA; UN Regional Remote Sensing

Program, ESCAP, Thailand; Global Inventory and Modelling Studies Group; International Satellite-Land-Surface-Climatology Project; and Global Environmental Monitoring System. Forecasts generated through the early warning system will be disseminated through radio, TV, and other mass media. Training courses will be arranged to acquaint provincial scientists with the remote sensing technology and use of processed information in decision making.

Expected accomplishments

- A remote sensing unit with physical facilities for digital analyses of satellite and airborne data, and construction of simulation models for crops and natural resources will be established at NARC.
- A team of trained scientists with a multidisciplinary background, capable of conducting remote sensing application programs in crops and natural resources will be created.
- A national natural resources inventory will be completed.
- Up-to-date qualitative and quantitative information regarding the condition of crops and natural resources of the country will be provided to provincial users, and government planners.

Agro-Forestry

Pakistan has a low forest cover (15% of its land mass). The primary reason is that 70 to 80% of Pakistan falls in the arid and semi-arid zones, where the precipitation is too low to support tree growth. At present, the country consumes 19 million cubic meters of fuelwood and 2.4 million cubic meters of timber annually. It is estimated that by the year 2000, demand will rise to 30.7 million cubic meters and 3.4 million cubic meters for fuelwood and timber, respectively. This demand cannot be met from state forests only. At present farmlands supply 90% of the fuelwood and 47% of the timber requirement. Agro-forestry could be help meet this demand. In agro-forestry, trees are grown with crops to increase overall yields of the land. But agro-forestry is not currently practiced on scientific lines: concerted research efforts are needed to popularize this agricultural system.

The major production problems are:

- Low wood productivity due to slow-growing trees on farmlands.
- Improper tree-growing techniques on farmlands.
- Inadequate information about proper combinations of trees and crops on farmlands.
- Lack of proper inventory and appraisal of the existing agro-forestry system.
- Inadequate application of agro-forestry technology, such as integrated land use, on farmers' fields.
- Lack of emphasis on growing trees in arid and semi-arid areas.
- Poor information on cost and benefits of agro-forestry systems.

Goals and objectives. The principal aims of the agro-forestry programme are:

- Increasing the production of timber, fuelwood, and forage from agricultural lands.
- Protecting farmlands against various erosive agencies and climatic extremes through trees.
- Maximizing farmers' incomes by intercropping suitable multipurpose tree species with crops.
- Promoting cottage industries like sericulture, apiculture, etc., by raising suitable tree species on farm lands.

Mandate. The agro-forestry project at NARC is to conduct research in various agro-forestry systems, which are not currently being undertaken. Under this project, technology packages will

be developed to increase the farmers' income by raising various multipurpose tree species on farm lands.

Current programme. Present activities include biomass study of Iple-Iple (*Leucaena leucocephala*) at various spacings at various age intervals, studies of the interaction of leguminous and non-leguminous trees, and silvo-pastoral trials.

Proposed programme

Priority 1

- Introduction and evaluation of various multipurpose tree and shrubs for agro-forestry purpose.
- Spacing, thinning, rotation trials for maximum biomass production of trees and crops.
- Compatibility of different trees and crop mixtures.
- Diagnostic survey and appraisal of existing farming system and agro-forestry practices (i.e. system, practices, productivity, and sustainability).
- Agro-forestry through integrated land use.
- Establishment of research and demonstration plots for interface studies and testing of parameters such as spacing design, effect of shade, allelopathy, shade tolerance, nutrient uptake, water use, mycorrhizal and nitrogen fixation.
- Silvo-pastoral development studies for incorporating animals, forage grasses, legumes, and trees.
- Palatability and nutrition status of different tree species for use as fodder.

Priority 2

- Prediction of future supply and demand and evaluation of marketing.
- Cost-benefit analysis of agro-forestry systems.

Linkages and relationships. On campus, collaboration will be developed with soil fertility, animal nutrition, and farming systems research. Collaboration will also be developed with various provincial forest departments for exchange of germplasm and literature. Linkages will be developed and strengthened with organizations like Pakistan Forest Institute, Pakistan Forest Research Institute, and Plant Introduction Centre for exchange of germplasm, technical assistance, etc. Linkages will be developed with ICRAF for exchange of literature, germplasm, and short-term training.

Expected accomplishments

- Suitable tree species will be identified which have less detrimental effect on farm crops through shading and competition and also bring benefits through fuelwood, fodder production, biological nitrogen fixation, soil conservation, and protection.
- Suitable multipurpose tree species for fuelwood, timber, forage, sericulture, etc. will be introduced and selected from local and exotic germplasm suited for the Pothwar tract.
- Fodder trees and shrubs compatible with forage grasses and legumes will be selected through silvo-pastoral studies for livestock ranching.
- Nutrient recycling of various tree species will be studied and those found suitable will be encouraged for intercropping and alley farming.

Forage and Pasture

Nearly two-thirds of Pakistan is categorised as rangelands, which is a major source of feed for nearly 93 million livestock. Because of overgrazing and unscientific use, rangelands are producing 10 to 50 percent of their potential. Rangelands are stocked with twice the number of

animals that they can support. Therefore, it is necessary to manage this vast natural resource on scientific lines so that sustained grazing of livestock can be ensured.

NARC is located in the subtropical, sub-humid Pothwar plateau where the rural economy is highly dependant on livestock rearing. Shortage of livestock feed and fuelwood are major constraints. Due to steep topography and danger of soil erosion, only half of the area can be cultivated. The remaining half is suited for range management and afforestation. Therefore concerted research efforts are needed to increase forage production and fuelwood in the area.

The major production problems are:

- Decline in range productivity due to decrease in desirable plants.
- Absence of proper range reseeding techniques in different range ecological zones.
- Unawareness of the high potential of fodder trees and shrubs in the arid and semi-arid areas.
- Lack of a suitable grazing system for Pothwar scrub ranges.
- Poor preservation of surplus forage during the monsoon season.
- Inadequate information on nutritional quality of forages.
- Ineffective biological nitrogen fixation in range areas.

Goals and objectives. The principal aims of the forage and pasture programme are:

- Collection and selection of local and exotic forage germplasm.
- Development of range improvement techniques and grazing systems.
- Evaluation of forage quality through biochemical analysis and feeding and digestion trials.
- Integration of improved forage and range technology into economically viable farming system.

Mandate. The forage and pasture programme will undertake research for development of a technology package for increased forage production in various ecological zones through introduction and selection of forage germplasm and agronomic trials to get maximum forage yields with existing resources. The package thus developed will be communicated to provincial agencies and institutes responsible for management of rangelands and farmers concerned through demonstrations, publications and other mass media. The forage unit NARC will provide technical assistance to other collaborating units in various ecological zones of the country.

Current programme. The forage and pasture programme consists of six units, including the forage and pasture unit, NARC, located throughout Pakistan. The forage and pasture unit, NARC, along with other units has the responsibility for collection, screening, evaluation, selection, and maintenance of forage germplasm. Agronomic trials are carried out for increased yield and quality of forages. A pasture, with selected forage legumes and grasses, is being established for demonstration. Seed multiplication of the promising forages and their distribution to various agencies and progressive farmers is also being practiced. The nutritional value of forages is being evaluated with the help of the animal sciences institute. Studies on physiology of forage plants are under way with collaboration of the stress physiology unit.

Proposed programme

Priority 1

- Collection and selection of local and exotic forage germplasm.
- Agronomic trials on forage legumes and grasses.
- Farming systems research on the ley-farming grazing system and economic feasibility of ranching.

Priority 2

- Preservation of forage through hay and silage.
- Nutrition value of forages trials.

Priority 3

- Forage physiology
- Biological nitrogen fixation in forage legumes.

Linkages and relationships. On campus, the forage programme will collaborate with animal nutrition, fodder crops, Barani Agricultural Research and Development, biological nitrogen fixation, plant introduction centre, plant genetic resources, farming systems research, and technology transfer unit. The programme will be linked with provincial forest and livestock departments, Sind Arid Zone Development Authority, Cholistan Institute of Desert Studies, Agency for Barani Area Development. On national level linkages will be developed with the Watershed and Arid Land Development Authority; Pakistan Forest Institute, Peshawar; University of Agriculture, Faisalabad; Arid Zone Research Institute; and Agricultural Research Institute for Northern Areas for exchange of technical advice and germplasm. This coordinated programme could assist Watershed and Arid Land Development Authority in the development of range management research and development plans for various range ecological zones of Pakistan.

The programme will collaborate with FAO, Utah State University, ICARDA, ICIMOD, CIAT and other similar organizations for exchange of germplasm, literature, and for short and long term training.

Expected accomplishments

- Various local and exotic species of grasses, legumes, forbs, shrubs and trees will be tested and evaluated and those having potential will be selected for large scale planting.
- A package of technology for each of the selected forage species will be developed to maximise forage quantity and quality.
- The seed of the selected species will be multiplied and distributed among farmers and various agencies engaged in the management of rangelands and forage production.
- Suitable species will be selected for problem soils e.g., eroded and arid soils and other problem soils.
- The technology for preservation of forage for lean periods will be developed for suitable species through hay and silage making.
- Studies on forage legumes for biological nitrogen fixation will lead to selection of some suitable legumes that increase soil fertility, produce high quality forage, and aid soil conservation.

Apiculture

Honeybees are haplodiploid and require continuous selective breeding to maintain quality characters. The oriental bee, *Apis cerana*, and the European bee, *A. mellifera*, need to be bred for gentleness, better ability to develop large populations, reduced swarming and stinging habit, and higher honey yield.

There are vast gaps between the average and potential honey yield per colony. The strains of the oriental and European bees and their management technologies, including control of pests and diseases, require further improvement in order to raise yields.

Honeybees are known to increase the yield of entomophilous crops, such as oilseeds, vegetable seed and fodder crops, and fruit plants, and in many countries are rented by farmers for

pollination of such crops. But in Pakistan the farmers know little about the uses of bees for such purposes. Therefore, honeybees need to be tested and demonstrated to farmers for pollination of entomophilous crops. The major production problems are:

- *Apis cerana* bees maintained by most beekeepers are almost wild and require improvement or replacement with high yielding strains.
- Pests and diseases of bees.

Goals and objectives. The principal aims of the apiculture are:

- To develop honeybee management technology with the local hive bee (*Apis cerana*) and the European bee (*Apis mellifera*) and to improve their strains for development of apiculture on sound scientific lines.
- To conduct further studies on the pollination potential of the honeybees in different varieties of entomophilous crops.
- To transfer modern honeybee management technology to the beekeepers and other interested persons so that beekeeping can flourish as a commercial and cottage industry in Pakistan.

Mandate. The honeybee research programme mandate is to conduct interdisciplinary research both for increasing honey production and yields of entomophilous crops. Research thrusts would include improvement in honeybee management technology, genetic improvement of bees for higher honey yield, and pollination of crops.

Current programme. The honeybee research programme, NARC, would screen and evaluate new varieties and strains of honeybees obtained from international sources and develop honeybee strains for heat and cold tolerance and disease resistance. The staff would be responsible for acquiring and maintaining improved strains of honeybees. Emphasis will be placed on research to solve major beekeeping problems particularly those which are not adequately covered by the provincial institutes.

Proposed programme

Priority 1

- Improvement of the management technology of *Apis cerana* and *Apis mellifera* and their strains for higher yields of honey.
- Collaborative studies on honeybee pollination potentials of various varieties of insect-pollinated crops such as rape and mustard, safflower, sunflower (oilseed crops); alfalfa and clovers (fodder seed crops); almond, apple, apricot, avocado, litchi, olive, peach, pear, persimmon, plum (fruit trees); carrot, cucumber, radish, eggplant or brinjal, onion, cole crops, pumpkin and squash (vegetable seed crops); and muskmelon and watermelon (melon crops).
- Transfer modern honeybee management technology for honey production and crops pollination.
- Strengthening of the honeybee unit's capability for cleaning, filtering and classifying honey according to the plant sources of nectar.

Priority 2

- Improvement and popularization of the harvesting methods of royal jelly, propolis, pollen, bee venom and wax.
- Improvement in the methods of protecting bees from pesticides, diseases, pests and pollution.
- Development of methods for prevention of post-harvest losses in honey.

Priority 3

- Biology of wild bee pollinations and improvement in methods of using wild bees for crop pollination.
- Standardization of methods of processing beekeeping products.
- Introduction of higher nectar-yielding plants.

Advanced research Specialized investigations will be conducted by this unit on pests and disease control, low cost beekeeping equipment, and honeybee management technology for honey production and crop pollination.

Linkages and relationships. On campus, the honeybee research programme would conduct research in cooperation with oilseeds, vegetables and fodder seed crops, fruit and farming systems research programmes. It will actively participate in the National Coordinated Honeybee Programme and will conduct experiments on various aspects of honeybee management for honey production and crop pollination in Islamabad area. The honeybee research programme will assist beekeeping associations in connection with importation of equipment, maintaining honey quality control, and training of members. Some site-specific research will be conducted in collaboration with oilseed, vegetable seed and fodder seed crops, and fruit programmes.

Honeybee research programme staff at NARC will receive genetic material of honeybees and literature on beekeeping from various international agencies including Apimondia, IBRA, and other beekeeping federations. The genetic material will be screened and evaluated by the programme staff and the provincial institutes.

The honeybee research programme will generate improved technology. Beekeeping societies will provide important means by which the beekeepers may validate improved honey management technology in their areas. The technology relating to honeybee pollination of entomophilous crops will be transferred through oilseed, fodder seed and vegetable crops, and fruit programmes including farming systems research, etc. The assessment will be made in the terms of increased honey production per colony and increased yield in crops.

Expected accomplishments

- Management technology of *Apis cerana* and *Apis mellifera* and their strains will be improved for higher yields of honey.
- The honeybee pollination potentials of various varieties of insect-pollinated crops will be assessed.
- Modern honeybee management technology for honey production and crops pollination will be transferred to beekeepers.
- Method of harvesting royal jelly, propolis, pollen, bee venom, and wax will be improved and popularised.
- Methods of protecting bees from pesticides, diseases, pests, and pollution will be improved.
- Methods for prevention of post-harvest losses in honey will be developed.
- The biology of wild bee pollinators will be studied and methods of using wild bees for crop pollination will be improved.
- Methods of detecting honey adulteration will be standardized and honey processing practices will be improved.
- Higher nectar (honey) yielding plants will be introduced.

Sericulture

The average silk yield is less than half of the potential yield. Since silk yield depends largely on the quality of the mulberry leaves offered to the larvae, selection of new mulberry varieties by

breeding and developing polyploids for more nutritious leaves is needed. Importation of eggs is the major constraint to the development of the industry. A centre to supply hybrid seed to farmers should be established. The major production problems are:

- Locally produced silkworm seed is substandard and the demand for seed is not being met.
- Diseases take a heavy toll on the silk harvest.
- Only one crop is harvested annually.
- Lack of mulberry species or varieties that produce a large volume of highly nutritive foliage per unit area.

Goals and objectives. The principal aims of the sericulture programme are:

- To develop silkworm management technology for production of three to four silk crops annually.
- To compare the silk production capabilities of various strains of silkworm.
- To investigate pests and diseases of silkworm and to develop control measures for them.
- To study selective breeding of silkworm for evolving pure lines to produce hybrid seed suitable for rearing under local climatic conditions.
- To introduce improved mulberry varieties for silkworm rearing and to study their foliage yield.
- To study measures to control pests and diseases of mulberry.

Mandate. The sericulture programme is to conduct research on mulberry species and to find varieties with higher foliage yield, more nutritious leaves, and longer sprouting period; to develop techniques to rear three to four crops per annum under the local conditions; to determine factors responsible for low cocoon yield; to conduct research on the use of hormones and vitamins for higher cocoon yield.

Current programme. Emphasis has been laid on evaluation of the 10 mulberry species and varieties planted at NARC for rearing silkworm, development of technology for mulberry cultivation to ensure a regular supply of foliage, and techniques for rearing three to four silkworm crops under the local climatic conditions. Hence packages of technology for silkworm rearing will be developed for the small farmers to get higher yields. A nursery of improved mulberry species and varieties will be established for distribution to the farmers.

Proposed programme

Priority 1

- Studies of silkworm management technology to maximize the number of silk crops possible in the Islamabad area.
- Breeding of silkworm to isolate pure lines for production of hybrid seed.
- Studies on modern techniques for mulberry cultivation in order to get maximum foliage per unit area.
- Studies to ensure regular supplies of mulberry foliage nearly year-round.

Priority 2

- Studies on diseases of silkworm and control measures.
- Studies on the effect of various insect hormones on development of silkworm and silk production.
- Importation and selection of mulberry for better yield and early sprouting.
- Studies on pests and diseases of mulberry.

Priority 3

- Storing of eggs and breaking of diapause in *Bombyx mori*.
- Studies on artificial diets for rearing silkworm.

Advanced research. Advanced research will be conducted on genetic manipulation of the silkworm for production of disease-resistant, heat tolerant, and high yielding strains.

Linkages and relationships. At campus, this unit will collaborate with agro-forestry, plant genetic resources, and plant protection. The wastes of sericulture industry are used in fish culture and these studies will be conducted with the cooperation of animal nutrition staff. The sericulture programme at NARC will work in cooperation and coordination with provincial units. After breeding of mulberry or establishment of pure lines their performance will be checked in different ecological areas. The programme will also have a close cooperation with Pakistan Forest Institute. Links will be established with sericulture research organizations in China, Japan, Korea and India.

Expected accomplishments

- Methods for getting four to five crops per annum from the imported silkworm seed or local hybrid seed will be developed.
- Pure lines of silkworm will be isolated for production of hybrid seed.
- Improved cultivation practises for getting maximum foliage per unit area from local, imported, or new varieties of mulberry will be developed.
- New techniques to ensure a regular supply of mulberry foliage will be developed.
- Control measures for diseases of silkworm will be developed.
- Insect hormones will be tested for increasing silk production and its quality.
- Better yielding and early sprouting varieties of mulberry will be selected.
- Pests and diseases of mulberry will be studied.
- Methods for investigation on storing of eggs and breaking of diapause in Bombyx mori will be developed.
- Artificial diets for rearing silkworm will be developed.

RESOURCE REQUIREMENTS:
NATURAL RESOURCES

SOIL SCIENCES - SOIL FERTILITY AND PLANT NUTRITION: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Evaluation of chemical indices for predicting N fertilizer requirements of crops.	1	2.5	10000	2.0	34000	2.0	60000	2.0	88000	2.0	125000	2.0	165000
2. Soil test calibration for determining P requirements of arable crops.	1	4.0	40000	2.0	51000	1.5	60000	2.0	137000	2.0	123000	2.0	166000
3. Development of methodology for site specific fertilizer recommendations.	1	-	-	-	-	1.5	60527	2.0	88000	2.0	120000	2.0	161000
4. Diagnosis and amelioration of nutritional problems in fruit crops.	1	-	-	2.0	18847	2.0	60000	1.0	49000	2.0	120000	3.0	240000
5. Diagnosis and correction of micronutrient disorders in crops.	1	3.0	20000	2.0	54000	2.0	60000	2.0	88570	2.0	120812	2.0	160000
6. Quantification of N losses under different ecosystems.	2	1.5	10000	2.0	34000	1.0	30000	1.0	44000	1.0	120000	2.0	160746
7. Management of soil fertility of salt affected soil used for rice based cropping.	2	-	-	1.0	17000	1.0	30000	1.0	44000	1.0	60000	1.0	80000
Total		11.0	80000	11.0	208847	11.0	360527	11.0	538570	12.0	788812	14.0	1132746

BUDGET		
	Staff Costs: Existing (1988/89 + 3%/year)	973728
	Additional	0
	Operational Funds	80000
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	1053728

1002940	1033028	1064019	1282988	1878423
0	0	0	66514	119536
208847	360527	538570	788812	1132746
1211787	1393555	1602589	2138314	3130705

* Number of scientists (BP 17-20) 2 PSO, 1 SSO, 8 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SOIL SCIENCES - SOIL CHEMISTRY AND MINERALOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Chemical and mineralogical studies on agricultural soils with implication on N, P and K fertilizer use.	1	3.0	50000	2.0	75929	1.5	130842	1.5	202247	3.0	255197	3.0	324440
2. Tracer studies on interactive effect of organic matter and soil mineralogical composition on crop nutrition	1	-	-	1.0	15286	1.5	35234	1.5	35000	3.0	46486	4.0	99837
3. Management of sulphur nutrition in soils under various crops with particular emphasis on oilseeds.	1	2.0	20000	1.0	23000	1.0	23958	1.0	35000	1.0	50000	1.0	71899
4. Use of industrial and municipal wastes for crop production and environmental pollution.	1	-	-	1.0	22000	1.0	33000	1.0	33000	1.0	40000	1.0	78182
Total		5.0	70000	5.0	136215	5.0	223034	5.0	305247	8.0	391683	9.0	574358

BUDGET							
	Staff Costs: Existing (1988/89 + 3%/year)	464292	478221	492557	507344	650538	952453
	Additional	0	0	0	0	42009	60611
	Operational Funds	70000	136215	214034	305247	391683	574358
	Total (1988/89 + 13%/yr through 1991/92, then + 10%/yr)	534292	614436	706601	812591	1084230	1587422

* Number of scientists (SP 17-20) 1 PSO, 2 SSO, 6 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SOIL SCIENCES - SOIL BIOLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Symbiotic biological N2 fixation (Legume inoculant).	1	2.0	30000	2.0	55000	2.0	67360	2.0	89000	1.0	68000	1.0	101500
2. Non associative N2 fixation crop residue utilization for N2 fixation - Fungal/Bacterial or Bacterial/Bacterial Consortium.	1	-	-	1.0	30000	1.0	33680	1.0	54000	1.0	86000	1.0	116500
3. Phosphorus Mobilising non-associative fungi (Hyphomycetes).	1	1.0	15000	1.0	26121	1.0	47902	2.0	88270	1.0	98500	1.0	112000
4. Biological inhibitors for reduced soil N2 efflux.	2	-	-	-	-	1.0	40000	1.0	49000	1.0	67500	1.0	106000
5. Sexual propagation techniques i. Azolla spp.	2	-	-	-	-	-	-	-	-	1.0	58000	-	-
6. Collection and maintenance of economic organisms.	2	-	-	-	-	-	-	-	-	1.0	52193	1.0	80800
7. Biological disinfestation of problem soils (root/wilt diseases).	3	-	-	-	-	-	-	-	-	-	-	1.0	101501
Total		3.0	45000	4.0	111121	5.0	188942	6.0	280270	6.0	430193	6.0	618301

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	494760	509603	524891	540638	700310	1025324
	Additional	0	0	0	0	36681	65248
	Operational Funds	45000	111121	188942	280270	430193	618301
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	539760	620724	713833	820907	1167184	1708873

* Number of scientists (BP 17-20) 3 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SOIL SCIENCES - SOIL PHYSICS: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Development of improved soil management practices alleviating physical soil properties effecting productivity.	1	2.0	27000	2.0	50000	2.0	76000	2.0	85000	1.0	70000	1.0	90000
2. Root behaviour of principal crops in relation to soil physical condition.	1	1.0	15000	1.0	30000	1.0	44000	2.0	85000	1.0	70000	1.0	90000
3. Moisture and solution movement in major soils of Pakistan in relation to crop production.	1	1.0	15000	1.0	25926	1.0	44674	1.0	61915	2.0	123214	2.0	185396
4. Aggregate stability for predicting/controlling soil loss.	1	1.0	15000	1.0	28000	1.0	42000	1.0	60000	2.0	100000	2.0	170000
Total		5.0	72000	5.0	133926	5.0	206674	6.0	291915	6.0	363214	6.0	535396

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	426048	438829	451994	465554	606409	887843
	Additional	0	0	0	0	41058	56499
	Operational Funds	72000	133926	206674	291915	363214	535396
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	498048	572755	658668	757469	1010681	1479738

* Number of scientists (BP 17-20) 1 PSO, 2 SSO, 6 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SOIL SCIENCES - STRESS PHYSIOLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
Influence of environmental stresses on reproductive physiology of crop plants													
1. Photosynthetic efficiency, source/sink relationship grain filling under salt, drought and temperature stress.	1	0.5	13000	0.5	20000	0.5	30000	0.5	45000	0.5	60000	0.5	90000
2. Hormones dynamics under salt, drought, and temperature stress in wheat and rice	1	0.5	7000	0.5	10000	0.5	12000	0.25	20000	0.5	25000	0.5	30000
3. Establishment of bio-chemical markers.	1	0.5	6000	0.25	10000	0.25	15000	0.25	15000	0.5	20000	0.5	25000
4. Molecular level of stress tolerance.	1	-	-	0.25	5000	0.25	10000	0.5	20000	1.0	28000	1.0	40000
Cultivation of non-conventional salt tolerant plants on problem soils of Pakistan													
5. Agro-industrial potential of non-conventional crops, on marginal lands.	1	0.5	8000	0.5	22807	0.5	30239	0.5	44318	0.5	50000	0.5	92000
6. Nutritional characteristics of tolerant plants for human and animal consumption.	1	0.5	2000	0.5	5000	0.5	10000	0.5	12000	0.5	20000	0.5	25000
7. Field trials, economics of selected stress tolerant plants for useful products.	1	0.5	4000	0.5	5000	0.5	15000	0.5	18000	0.5	38624	0.5	25931
Total		3.0	40000	3.0	77807	3.0	122239	3.0	174318	4.0	241624	4.0	327931

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	265056	273008	281198	289634	371427	543807
	Additional	0	0	0	0	23994	34606
	Operational Funds	40000	77807	122239	174318	223624	327931
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	305056	350814	403437	463952	619045	906344

* Number of scientists (BP 17-20) 1 PSO, 1 SSO, 4 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

WATER RESOURCES - SOIL AND WATER CONSERVATION: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Soil & Water Conservation database covering soil, water vegetation and climatic aspects for research done in Pakistan and elsewhere.	1	9.0	301500	6.0	354230	4.0	373027	3.0	297329	3.0	353636	3.0	350265
2. Simulation of rainfall-runoff-soil loss functions and validations using data collected at research sites.	1	-	-	2.0	101210	2.0	149209	2.0	198219	3.0	235755	3.0	350265
3. Simulation of resource management strategies and validations using integrated land use data collected at research sites.	1	-	-	1.0	50604	2.0	149209	2.0	198219	2.0	235755	3.0	350265
4. Conservation tillage and development of tillage index for Barani areas.	2	-	-	-	-	1.0	74604	1.0	198219	2.0	235755	2.0	350265
5. Development of soil-water-plant relationships for selected plants related to Barani conditions.	2	-	-	-	-	-	-	1.0	99111	2.0	117877	2.0	350265
Total		9.0	301500	9.0	506044	9.0	746049	9.0	991097	12.0	1178778	13.0	1751325

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	1327656		1367486		1408510		1450766		1983613		2904207
	Additional	0		0		0		35880		143630		184813
	Operational Funds	301500		506044		746049		991097		1178778		1751325
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	1629156		1873529		2154559		2477743		3306021		4840345

* Number of scientists (BP 17-20) 1 PSO, 2 SSO, 6 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

WATER RESOURCES - IRRIGATION SYSTEMS AND MANAGEMENT: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Improving water use and application efficiency at the farm level for Barani areas with supplemental irrigation.	1	6.0	138000	5.0	216183	4.0	288148	3.0	298288	3.0	236514	3.0	351393
2. Design and layout of improved water delivery system at the farm level for Barani area with supplemental irrigation.	1	-	-	1.0	24021	1.0	36018	1.0	99428	1.0	118257	1.0	87848
3. Computerized irrigation management strategies at the farm level for Barani areas.	1	-	-	-	-	-	-	1.0	49714	1.0	118257	1.0	131772
4. Irrigation and energy scheduling at the farm level for Barani areas with supplemental irrigation.	2	-	-	-	-	1.0	36018	1.0	49714	1.0	59128	2.0	175696
5. Development of soil-water-plant relationships for wheat, soybean and maize under supplemental irrigation.	2	-	-	-	-	-	-	-	-	1.0	59130	1.0	131722
Total		6.0	138000	6.0	240204	6.0	360184	6.0	497144	7.0	591286	8.0	878431

BUDGET													
	Staff Costs: Existing (1988/89 + 3%/year)		679200		699576		720563		742180		994999		1456778
	Additional		0		0		0		3535		72046		92704
	Operational Funds		138000		240204		360184		497144		591286		878481
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)		817200		939780		1080747		1242859		1658331		2427963

* Number of scientists (BP 17-20) 1 SSO, 5 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

WATER RESOURCES - AGRO-METEOROLOGY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Development of agromet database in collaboration with PMD & WAPDA.	1	3.0	16000	1.0	30997	0.5	37468	0.5	28602	1.0	40000	1.0	55000
2. Climatological and micro-climatological studies for irrigated and rainfed farming systems.	1	-	-	1.0	15498	1.0	28103	0.5	28603	1.0	40000	2.0	55000
3. Prediction of evapotranspiration using climatic data.	1	-	-	1.0	5168	0.5	9367	0.5	28602	1.0	40000	1.0	55000
4. Drought and flood management for agriculture.	2	-	-	-	-	0.5	9367	0.5	28602	1.0	40000	1.0	55000
5. Yield forecast simulations and validations using field data.	2	-	-	-	-	0.5	9367	0.5	14301	0.5	30000	1.0	55000
6. Pests and disease infestation forecasts and validation using field data.	2	-	-	-	-	-	-	0.5	14301	0.5	30196	1.0	40174
Total		3.0	16000	3.0	51663	3.0	93672	3.0	143011	5 0	220196	7.0	315174

BUDGET									
Staff Costs: Existing (1988/89 + 3%/year)	277188	285504	294069	302891	358053	522650
Additional	0	0	0	0	16713	33260
Operational Funds	16000	51663	93672	143011	220196	315174
Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	293188	337166	387741	445902	594962	871084

* Number of Scientists (BP 17 - 20) 3 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

ECOLOGY: Resource Requirements

Project Title	Priority	1988 / 89 Staff*	1988 / 89 Op.F**	1989 / 90 Staff	1989 / 90 Op.F	1990 / 91 Staff	1990 / 91 Op.F	1991 / 92 Staff	1991 / 92 Op.F	1992/93-1995/96 Annual average Staff	1992/93-1995/96 Annual average Op.F	1996/97-1999/00 Annual average Staff	1996/97-1999/00 Annual average Op.F
1. Global Watch	1	1.0	12512	1.0	100000	1.0	100000	1.0	100000	1.0	150000	1.0	200000
2. Habitat Reclamation	2	3.0	210000	3.0	155889	3.0	235526	3.0	328346	3.0	252497	3.0	397995
Total		4.0	222512	4.0	255889	4.0	335526	4.0	428346	4.0	402497	4.0	597995

BUDGET	Staff Costs: Existing (1988/89 + 3%/year)		333768		343781		354094		364717		677310		991650
	Additional		0		40052		46060		52969		49043		63105
	Operational Funds		222512		255889		335526		428346		402497		597995
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)		556280		639722		735680		846032		1128850		1652750

* Number of Scientists (BP 17-20) 1 SSO, 3 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

REMOTE SENSING: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Establishment of a remote sensing unit.	1	5.0	51000	3.0	102271	3.0	170241	-	-	-	-	-	-
2. Compilation of a national natural resources inventory.	2	-	-	-	-	-	-	2.0	161718	2.0	151046	2.0	239965
3. Development of an early warning system for stress in crops.	2	-	-	-	-	-	-	1.0	90000	1.0	200000	1.0	300000
4. Construction of canopy reflectance model for various crops.	3	-	-	2.0	15000	2.0	25000	2.0	35000	2.0	50000	2.0	40000
Total		5.0	51000	5.0	117271	5.0	195241	5.0	286718	5.0	401046	5.0	579966

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	488508	503163	518258	533806	656889	961751
	Additional	0	0	0	0	36880	61202
	Operational Funds	51000	117271	195241	286718	401046	579966
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	539508	620434	713499	820524	1094815	1602919

* Number of scientists (BP 17-20) 1 PSO, 1 SSO, 3 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

AGRO-FORESTRY: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Introduction and evaluation of various multipurpose tree and shrubs for agro-forestry purposes.	1	0.4	10000	0.4	17000	0.4	20000	0.4	20000	0.4	20000	0.4	36000
2. Spacing, thinning, rotation trials for maximum biomass production of trees and crops.	1	0.4	10000	0.4	17000	0.4	20000	0.4	20000	0.4	20000	0.4	31000
3. Compatibility of different trees and crops. mixtures.	1	0.4	10000	0.4	16000	0.4	20000	0.4	20000	0.4	20000	0.4	31000
4. Diagnostic survey and appraisal of existing farming system and agro-forestry practices (i.e. system, practices, productivity and sustainability).	1	0.4	20000	0.4	30000	0.4	40000	0.4	30000	0.4	30000	0.4	46000
5. Agro-forestry through integrated land use.	1	0.3	10000	0.3	15653	0.3	33229	0.4	30000	0.4	30000	0.4	46000
6. Establishment of research and demonstration plots for interface studies and testing of parameters such as spacing design, effect of shade, allelopathy, shade tolerance, nutrient uptake, water use, mycorrhizal and Nitrogen fixation.	1	0.4	14000	0.4	15000	0.4	20000	0.4	20000	0.4	28000	0.4	38000
7. Silvo-pastoral development studies for incorporating animals, forage grasses, legumes and trees.	1	0.4	10000	0.4	15000	0.4	20000	0.4	20000	0.4	28000	0.4	38000
8. Palatability and nutrition status of different tree species for use as fodder.	1	0.3	10000	0.3	15000	0.3	20000	0.4	20000	0.4	28000	0.4	38000
9. Prediction of future supply and demand and evaluation of marketing strategy.	2	-	-	-	-	-	-	0.4	24326	0.4	32294	0.4	50664
10. Cost benefit analysis of agro-forestry systems.	2	-	-	-	-	-	-	0.4	20000	0.4	28000	0.4	38000
Total		3.0	94000	3.0	140653	3.0	193229	4.0	224326	4.0	264294	4.0	392664

BUDGET									
	Staff Costs: Existing (1988/89 + 3%/year)	271272	279410	287792	296426	444744	651150
	Additional	0	0	2051	34781	32203	41437
	Operational Funds	94000	140653	193229	224326	264294	392664
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	365272	420063	483072	555533	741241	1085251

* Number of scientists (BP 17-20) 1 SSO, 2 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

FORAGE AND PASTURE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Collection and selection of local & exotic forage germplasm.	1	1.0	10000	1.0	30887	1.0	50386	1.0	70000	1.0	125000	1.0	180000
2. Agronomic trials on forage legumes and grasses.	1	2.0	8000	2.0	25000	2.0	40000	2.0	65000	2.0	110000	2.0	150000
3. Farming system research on ley-farming grazing system & economic feasibility of ranching.	1	1.0	8000	1.0	20000	1.0	40000	1.0	65000	1.0	105000	1.0	130000
4. Evaluation and adaptation trials of fodder trees and shrubs.	1	1.0	8000	1.0	20000	1.0	32000	1.0	55000	1.0	85000	1.0	113364
5. Reseeding of improved grasses legumes fodder trees and shrubs in high rainfed mountain areas.	1	1.5	8000	1.5	20000	1.0	32000	1.0	50687	1.0	80943	1.0	100000
6. Preservation of forage through hay and silage.	2	0.5	5000	0.5	19000	0.5	30000	0.5	45000	0.5	70000	0.5	100000
7. Nutritional value of forages trials.	2	0.5	4000	0.5	18000	0.5	30000	0.5	42000	0.5	55000	0.5	90000
8. Forage physiology.	3	0.5	4000	0.5	18000	0.5	27000	0.5	38000	0.5	45000	1.0	80000
9. Biological N-fixation in forage legumes.	3	-	-	-	-	0.5	26000	0.5	37000	0.5	39000	1.0	80000
Total		8.0	55000	8.0	170887	8.0	307386	8.0	467687	8.0	714943	9.0	1023364

BUDGET													
	Staff Costs: Existing (1988/89 + 3%/year)		896976		923885		951602		980150		1161735		1697036
	Additional		0		0		0		0		55152		107993
	Operational Funds		55000		170887		307386		467687		714943		1023364
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)		951976		1094772		1258988		1447836		1931830		2828393

* Number of Scientists (BP 17-20) 1 SSO, 7 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

APICULTURE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Improvement of the management technology of Apis cerana and Apis mellifera and their strains for higher yields of honey.	1	1.0	30000	1.0	50000	1.0	70000	1.0	100000	2.0	125000	2.0	200000
2. Collaborative studies on honeybee pollination potentials of various varieties of insect-pollinated crops such as rape and mustard, safflower, sunflower (oilseed crops), alfalfa and clovers (fodder seed crops), almond, apple, apricot, avocado, litchi, olive, peach, pear, persimmon, plum (fruit trees), carrot, cucumber, radish, egg-plant or brinjal, onion, cole crops, pumpkin and squash (vegetable seed crops), musk melon and water melon (melon crops).	1	0.6	30000	0.6	50000	0.6	100000	0.6	135000	2.0	150000	2.0	250000
3. a. Transfer of modern honeybee management technology for honey production and crop pollination.	1	0.1	5000	0.1	15000	0.1	25000	0.1	30000	0.5	40000	0.5	50000
b. Strengthening of honeybee unit for cleaning, filtering and classifying honey according to the plant sources of nectar.	1	0.3	15000	0.3	35000	0.3	65000	0.3	80000	1.0	95000	1.5	150000
4. Improvement and popularization of the harvesting methods of royal jelly, propolis, pollen, bee venom and wax.	2	0.2	10000	0.3	20000	0.3	25000	0.3	35000	0.5	40000	1.0	100000

continued

APICULTURE (continued)

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
5. Improvement in the methods of protecting bees from pesticides, diseases, pests and pollution.	2	0.2	12000	0.3	20000	0.3	25000	0.3	40000	0.5	60000	1.0	100000
6. Development of methods for prevention of post-harvest losses in honey.	2	0.2	10000	0.1	10000	0.1	15000	0.1	35000	0.5	45000	-	-
7. Biology of wild bee pollinators and improvement in methods of using wild bees for crop pollination.	3	0.2	10000	0.2	15000	0.2	30000	0.2	45000	0.4	50000	0.8	100000
8. Standardization of methods of beekeeping products processing practices.	3	0.2	10000	0.1	15000	0.1	20000	0.1	30000	0.3	35000	-	-
9. Introduction of higher nectar (honey) yielding plants.	3	1.0	10000	1.0	27313	1.0	17744	1.0	21394	0.3	32593	0.2	44843
Total		4.0	142000	4.0	257313	4.0	392744	4.0	551394	8.0	672593	9.0	994843

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	783444	806947	831156	856090	1126793	1649738
	Additional	0	0	0	0	78603	104983
	Operational Funds	142000	257313	392744	551394	672593	994843
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	925444	1064261	1223900	1407485	1877989	2749564

* Number of Scientists (BP 17-20) 1 CSO, 1 PSO, 2 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

SERICULTURE: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Studies on silkworm management technology for getting maximum crops in Rawalpindi/Islamabad area.	1	0.3	10000	0.2	10000	0.2	10000	0.2	15000	0.2	20000	0.2	30000
2. Breeding of silkworm for isolation of pure lines for production of hybrid seed.	1	0.3	10000	0.2	10000	0.2	10000	0.2	10000	0.2	10000	0.2	15000
3. Studies on modern techniques for mulberry cultivation in order to get maximum foliage per unit area.	1	0.2	5000	0.2	10000	0.2	10000	0.2	5000	0.2	10000	0.2	10000
4. Studies to get regular supply of mulberry foliage.	1	0.2	3240	0.1	5000	0.2	10000	0.1	5000	0.1	5000	0.1	10000
5. Studies on silkworm diseases and control measures.	2	-	-	0.1	5000	0.1	5000	0.1	5000	0.1	5000	0.1	15000
6. Studies on effect of various insect harmones on development of silkworm and silk production.	2	-	-	0.2	7046	0.1	5000	0.2	20000	0.2	20000	0.2	20000
7. Importation and selection of mulberry for better yield and early sprouting.	2	-	-	-	-	0.3	5000	0.3	5000	0.3	10000	0.3	10000
8. Studies on pests and diseases of mulberry.	2	-	-	-	-	0.3	5000	0.3	5000	0.3	10000	0.3	20000
9. Storing of eggs and breaking of diapause in Bombyx mori.	3	-	-	-	-	0.4	5220	0.2	5000	0.2	10000	0.2	10000
10. Studies on artificial diet for rearing silkworm.	3	-	-	-	-	-	-	0.2	3546	0.2	8284	0.2	20878
Total		1.0	28240	1.0	47046	2.0	65220	2.0	78546	2.0	108284	2.0	160878

BUDGET								
	Staff Costs: Existing (1988/89 + 3%/year)	121416	125058	128810	132675	182217	266784
	Additional	0	0	3890	16388	13194	16977
	Operational Funds	28240	47046	65220	78546	108284	160878
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	149656	172104	197920	227608	303695	444639

* Number of scientists (BF 17-20) 1 SSO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

OTHER PROGRAMMES

Agricultural Economics

During the course of introduction of new biological technologies, many were found to be economically unviable or unsuitable for farmers' socio-economic circumstances. The discipline of agricultural economics was established at the research institutes to provide regular feedback on technology verification, adoption, and farmers' circumstances and to study on other farm-level issues. The major economic issues affecting production are:

- Slow adoption of improved farm technology by small farmers.
- Improved technology favours the large farmers.
- Inadequate information on farm costs and returns and resource allocation.
- Inefficient harvest and post-harvest handling of different crops.
- Paucity of information on post-harvest technology.

PARC has set up five agricultural economics research units, one each at NARC, Islamabad, and the provincial agricultural research institutes at Faisalabad, Tandojam, Tarnab, and Quetta under the World Bank-funded project PARDP. These units are in their infancy and need proper institutional support.

Goals and objectives. The principal aims of the agricultural economics research unit are:

- To identify on-farm problems and translate them into research priorities for appropriate recommendation domains.
- To determine the socio-economic viability of alternative technologies, to identify farm-level constraints to their adoption, and in the process to specify requirements for technology redesign, and to highlight areas for policy interventions.
- To evaluate social benefits and costs of new technologies.
- To arrange training workshops, symposia, and conferences in order to assist biological and social scientists covering concepts relevant to agricultural research.
- To conduct macro-level studies of specific commodities.

Mandate. The agricultural economic research unit, NARC, is to address on-farm testing of new agricultural technology, identification and measurement of the impact of the biological and socio-economic factors restricting crop yields in farmers' fields, economics of inputs use, and farm management studies. In addition, being at the federal level, the unit needs to concentrate on macro level researchable issues: returns to alternative investments in agricultural research; farm income analysis and its implications; farming systems research; and forecasting models for major crops with respect to production and imports etc.

Current programme. The agricultural economics research unit, NARC, began work in 1984. Major emphasis has been placed on micro or enterprise-level research. As the unit is located in the rainfed area, the research activities are mainly directed to the problems of the barani farming systems, which are more vulnerable to climatic variations than farming systems in the irrigated areas. The topics of current studies are the economics of intercropped rapeseed and mustard production in the Punjab barani tract, economic analysis of fertilizer response of wheat in rainfed northern Punjab, farmers' drought management strategies in rainfed northern Punjab, farmers' decisions to adopt a new crop sunflower, and economics of farming systems research interventions for crops and livestock in northern Punjab.

Proposed programme

Priority 1

- Comparative economics of crops and livestock enterprises with a farming system perspective.

- Setting commodity research priorities for farming systems.
- Farm productivity, resource availability, and constraints.
- Farmers' risk management.
- Soil conservation and moisture management.
- Profitability analysis and domestic resource cost of major crops and livestock.
- Returns to investment in agricultural research.

Priority 2

- Assessing alternative technologies.
- Watershed management and agro-forestry.
- Evaluation and impact studies.
- Farm budget analysis service.
- Economic analysis of improved farmers' recommendations.

Priority 3

- Economic analysis of input supplies.

Linkages and relationships. The social sciences discipline in Pakistan's agriculture system is weak and suffers from inadequacy of internal and external linkages amongst the various research agencies. The agricultural economics research units have set a good precedent by promoting internal linkages between social and biological scientists. At the national level, the unit collaborates with the provincial agricultural research institutes and the provincial agricultural economic research units. The unit also collaborates with international institutions such as CIMMYT, IRRI, ICRISAT, ICARDA, IBSNAT, and others. Training courses on such topics as economic analysis of experimental data, agro-economic research methodology data (with collaboration of the computer and statistics section, NARC) and agricultural modeling for decision making are offered frequently.

Expected accomplishments

- Economic analysis of alternative technology will help raise the income of the farming community by making crop and livestock enterprises more efficient.
- Economic analysis of technological options will lead to recommendations for purchased inputs like fertilizer, pesticides, seed, and farm machinery.
- Economic analysis of alternative technologies will assist biologists in preparation of economically feasible and technically sound recommendations for control of environmental degradations like soil erosion, water logging and salinity.
- Understanding the comparative advantage of import substitutions with respect to major commodities like oilseeds, vegetables, livestock, dairy products, and animal feed will help planners decide between local production and importation.
- Economic analyses of research investment will help research managers with programme analysis and planning.

Computer and Statistical Services

The use of biometrical principles in agricultural research can ensure that valid experimental results are obtained with a maximum amount of precision subject to resource limitations available for the experiment. The consequences of not adequately considering biometrical principles in the conduct of agricultural research can be disastrous. Experimental results may have no generality, which from a scientific perspective means the data are not statistically sound. Conclusions may not be valid or may not apply to the population or conditions of interest. Hypotheses may be impossible to test due to vaguely specified objectives and poor planning. Poorly planned experiments with low power are not likely to produce new knowledge and may be a waste of time

and money. Hence, it is imperative that the principles of statistical design and analysis are applied in the conduct of agricultural research.

Goals and objectives. The principal aims are:

- To suggest efficient and economical experimental designs and lay-outs for field experiments at NARC.
- Statistical analysis and interpretation of the experimental data generated by various research programmes.
- To conduct research on biometrical techniques such as optimum plot size, shape, sampling techniques, and relative efficiency of various experimental designs.
- To organize and conduct training courses for scientists on statistical methods and experimental design.
- To organize seminars and lectures on biometry and agricultural statistics.
- To provide subject-matter input for the agricultural statistical data-bank of PARC.
- To develop and test statistical software for the analysis of research data.

Mandate. The computer and statistics unit is to assist scientists of NARC in the design, conduct, analysis, and interpretation of experiments, to conduct research on new biometrical techniques and applications of advanced biometrical procedures in agricultural research, and to provide training in basic and advanced applications of biometrical principles and techniques in agricultural research.

Current programme. At present, the scientific staff of the unit devotes 40 percent of its time to statistical consultancy and biometrical research. Only 20 percent is allocated for statistical computing and training activities, because of shortage of scientific manpower. Even to continue the present activities effectively about 5 scientists are needed. To this end, we now encourage the scientists to undertake data analysis work by themselves on their own microcomputers. However, statistical consultancy and biometrical research will receive top priority in the future programme of work.

Proposed programme

Priority 1

- Study optimum plot size and shape of plots for agricultural research on crops of Pakistan.
- Study optimum size and number of quadrats for sampling vegetation.
- Study factors affecting the comparative efficiency of different types of experimental designs.
- Organize training course on statistical procedures and computer applications.
- Provide statistical advisory and computing services to NARC scientists.

Priority 2

- Development of procedures for controlling variability by adjustment of yield of nearest neighbours.
- Study clustering methods for grouping plots into uniform blocks.
- Application of non-iterative robust methods for handling problem data.

Linkages and relationships. The statistics unit is partly a support service and provides statistical consultancy on biometrical problems and conducts short-term training courses. As such, it has direct linkages with all the research programmes and projects located at NARC. Collaboration with the statistical units of the provincial agricultural research institutes would be developed through organizing training courses, exchange of research material, exchange of statistical software and mutual visits and exchange of views. Collaboration with the statistics

departments of the universities will be sought by inviting guest lectures on special topics, exchange of research journals and articles, and exchange of statistical software.

Agricultural Machinery

Pakistan's agriculture is confronted with the challenge of increasing yields by about 5% a year and reduction of harvest and post-harvest losses to 2%. To meet the targets, machines for sowing on time and applying fertilizer properly are necessary for good crop establishment. Harvesting on time and in an efficient manner reduces harvest and post-harvest losses. The promotion of organized animal production (feed lot system) is essential for the economical availability of quality milk and meat products.

The major production problems are:

- Shortages of labour at harvest time.
- Harvesting periods restricted by the need to plant the next crop promptly.
- Significant losses during post-harvest handling and storage.
- Low yields due to improper planting.
- Labour shortages and technical difficulties in preparing land and transplanting of rice.
- Large-animal herd management, particularly milking and animal waste management.

Goals and objectives. The principal aims of the Farm Machinery Institute are to develop and commercialise the seed-cum-fertilizer drill, the row-crop planter, the inter-row rotary cultivator, and the sugarcane seed-set cutter, and to popularise the sugarcane planter.

Mandate. The Farm Machinery Institute is to provide research and development services and facilities to the industrial and agricultural research sectors in Pakistan.

Current programme. At present, the Farm Machinery Institute is working on a low-cost, tractor-operated combine, a seed-cum-fertilizer drill, direct seeding of rice, evaluation of improved hand tools, development of sugarcane seed cutter, tillage research, and development of a pulses thresher.

Proposed programme

Priority 1

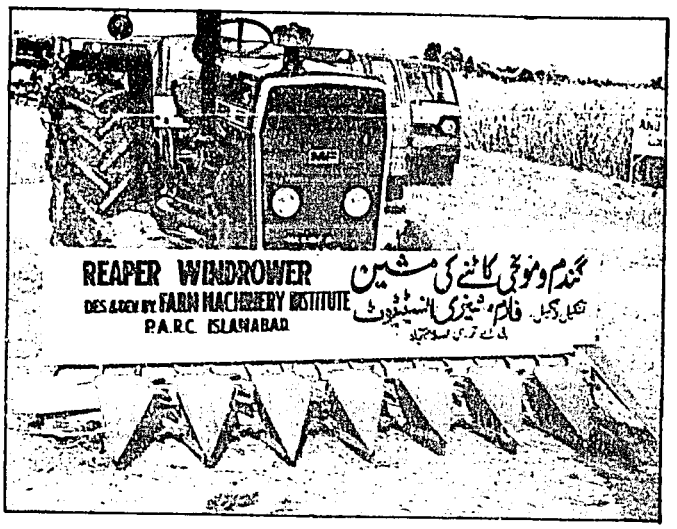
- Development of harvesting and threshing machines for cereals and oilseeds.
- Installation and operation of "on-time data acquisition" and processing system.
- Development of bulk grain trucks and bulk grain silos with loading and unloading and grain drying.
- Modelling of mechanization impact and machinery demand.
- Design and installation of protected agricultural structures.
- Studies of improved soil preparation, seeding and planting equipment under barani and irrigated conditions.
- Development of milking equipment for buffaloes.

Priority 2

- Studies on animal waste management.
- Studies on animal housing.

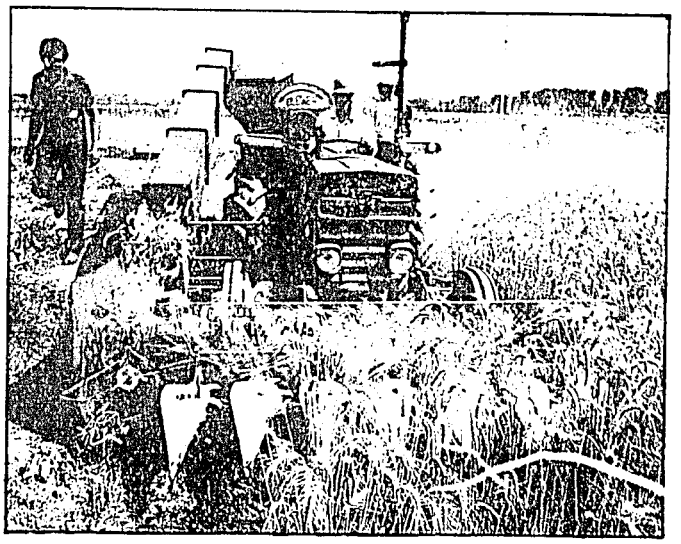
Advanced research. Advanced research will include computerised testing and designing procedures, and controlled environment agriculture.

Linkages and relationships. On campus, the Farm Machinery Institute will continue to support the commodity programmes for their hardware needs through local industry. Farm

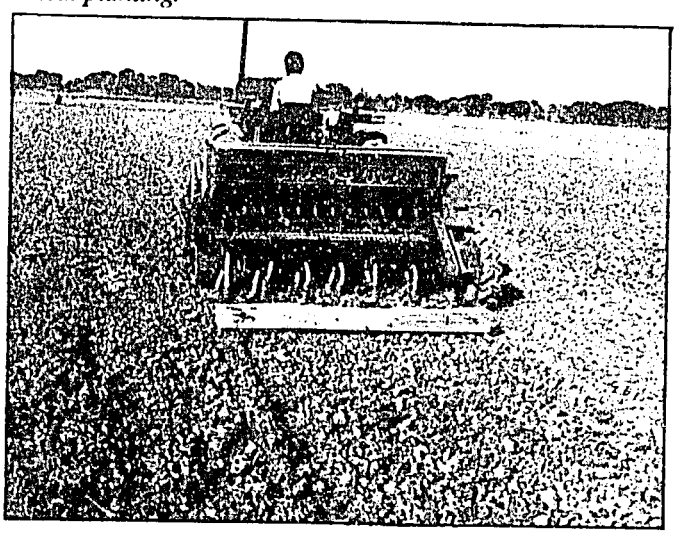


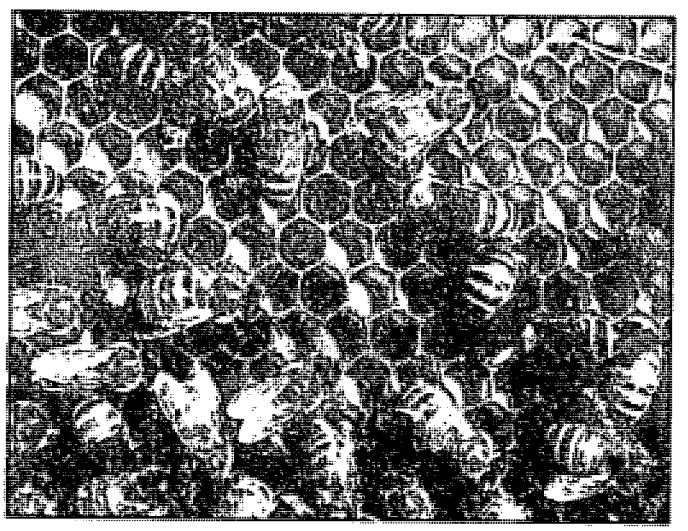
Private companies have developed reaper windrowers based on prototypes of Farm Machinery Institute, NARC, which have been widely adopted by farmers. This tractor-mounted reaper can harvest 0.4 to 0.5 hectare of wheat and rice crops per hour.

A low-cost whole crop harvester, mostly using the local materials and technology, has been developed by NARC. This tractor-operated machine can harvest about half a hectare of wheat crop per hour, and also produces fine "bhoosa" for livestock consumption.



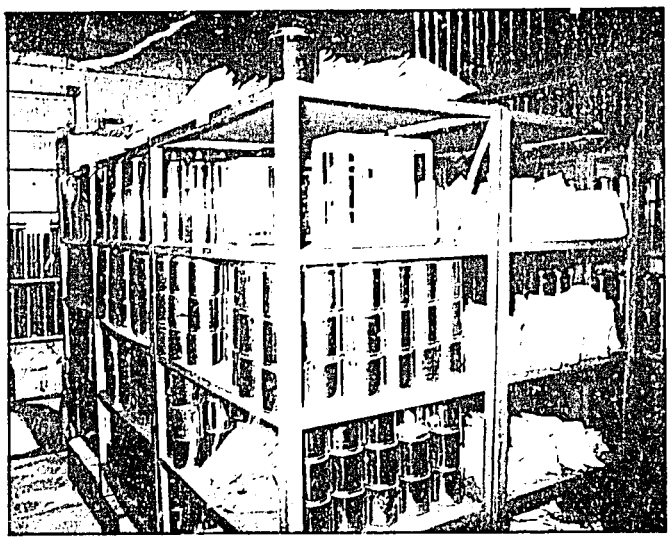
NARC provides support services, including the Farm Machinery Institute, which collaborates with various private sector firms in the design and testing of farm machinery such as the zero tillage planter now used by farmers for wheat planting.

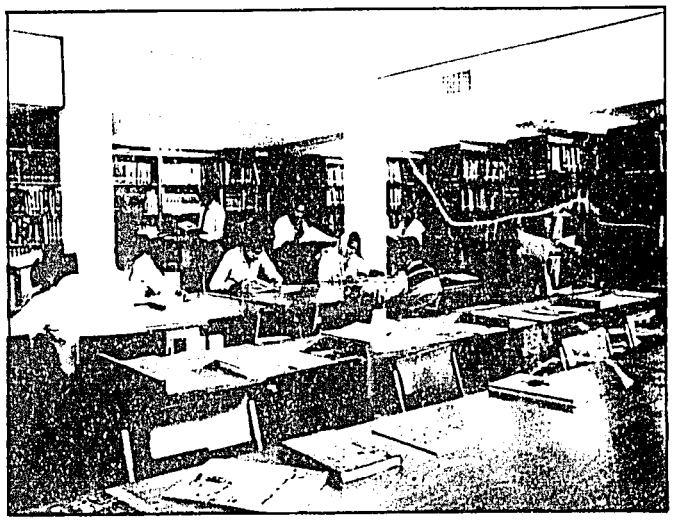




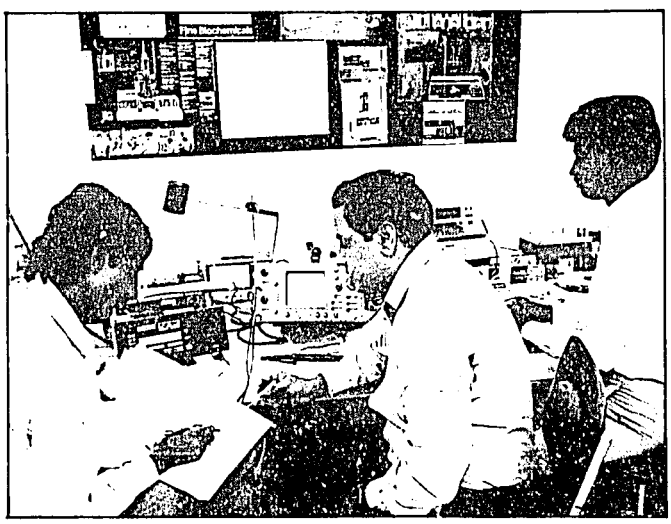
European honeybees have been imported and successfully reared which yield 3-4 times more honey as compared to the local bee species.

The NARC genebank contains valuable germplasm of many important crop cultivars useful in breeding studies. Collection, characterization and development of crops and varieties is done in partnership with provincial institutes.



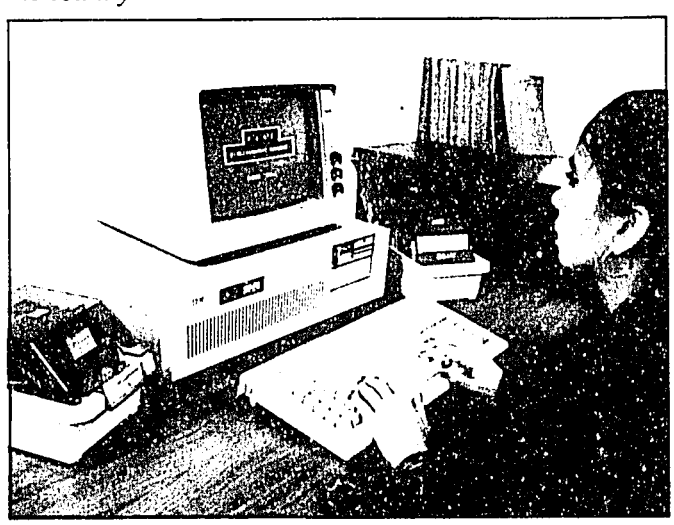


Modern library facilities which contain recent volumes of most significant agricultural/livestock journals and library services interconnected with scientists and libraries throughout the world.



Repair and maintenance of expensive and sophisticated experimental equipment is a NARC support service available to provincial and federal scientists.

NARC documentation centre has established a number of computerized bibliometric databases to serve the information needs of the agricultural scientists throughout the country.



Machinery Institute cooperates closely with the only similar provincial institution in the country—AMRI in Multan. This cooperation and mutual research will be further strengthened. Special needs of other centres have been met by, for example, erection of glass house at agricultural research institutes in Swat and Tarnab. The Farm Machinery Institute has been cooperating with AFRC-IER, UK, for 4 years resulting in the development of a combine.

Expected accomplishments

- The following locally manufactured machines will be on the market: improved threshers for all major crops such as wheat, rice, lentils, groundnut, sunflower, rape, and mustard; tractor-operated combines for wheat, rape-mustard, and groundnut; self-propelled combine for wheat, rice, and sunflower.
- Fully computerised design and testing facilities will be in operation.
- A modern multicrop seed-drill and pneumatic planter will be available from local manufacturing.
- Equipment for bulk handling and storage of grain will be available from local industry. The proper drying of grain especially rice and oilseeds will be promoted.
- A basis and expert system for determining farm machinery impact and demand will be rationalised and completed.
- The local availability of milking and chilling equipment along with large scale biogas technology will become the basis for promoting feedlot animal farming in Pakistan.
- A knowledge base, trained personnel, and manufacturing facilities will emerge permitting the construction, operation, and maintenance of controlled environment houses for growing high value crops.
- A knowledge base for tillage needs, required implements, and appropriate operation and maintenance skills will be available locally.

Farming Systems Research

Most agricultural research in Pakistan has been commodity oriented, that is, aimed at increasing the productivity of a specific crop—maize, wheat, etc. The benefits of this approach have not been as high as expected. It is now clear that the farmer's productivity is the result of a complex set of factors which form the basis for farming systems research. Farming systems research provides understanding of major resources and circumstances of the farmers. Agricultural research also becomes more relevant to solving production and management constraints. Policy makers and planners benefit from pertinent information as on-farm generated data provides a basis for important policy decisions. Farming systems research is multidisciplinary and often requires inter-agency collaboration to solve complex problems which constrain farmer productivity.

The major production problems are:

- Few experienced interdisciplinary teams are available to plan and conduct farming systems research.
- Little information is available to farmers on soil-plant-animal management interactions.
- Inadequate farmer testing of new technology results in low percentage of farmer adoption.
- Insufficient understanding of the importance of farm budget analysis and farmer interviews preclude valuable assessment of improved technology.

Goal and objectives. The principal aims of the farming systems research programme are:

- To develop a capability in the diagnosis and analysis of farmer constraints with

suggested improved resource allocation to optimise farm productivity and maximise net farm income.

- To establish interdisciplinary competence in the design and execution of improved technology for farmer testing and system assessment.
- To strengthen linkages between research, extension, and education in the public and private sector.
- To improve farming systems research methodology, impact studies, and capability to conduct component experiment station research that supports farming systems research projects.
- To encourage the transfer and communication of improved technology.

Mandate. The NARC farming systems research unit mandate is to evaluate technologies of various commodity programmes in an integrated system suitable to socio-economic conditions of barani farmers. This includes backstopping multidisciplinary research at the station.

Current programme. The farming system research unit at NARC mainly relies on the staff of various commodity programmes. Forage, fodder, and improved husbandry to solve livestock production problems of barani land constitute a major farming systems research thrust. Scientists from the livestock and fodder programmes, agro-forestry, and economics are working together. In addition, the introduction of sunflower into the wheat-fallow-wheat system is under study. These farming systems research efforts aim to not only improve the income of the farmers but also to increase oilseed production. Sunflower is being compared with other crops like maize, sorghum, and pulses. Each improved system involves agricultural economists to assess the comparative profitability. Work on role of women in agriculture has been initiated and major constraints identified. Improved technologies to benefit rural women are being developed.

Proposed programme

Priority 1

- Testing of improved fodder technology in the wheat-based barani cropping system and its integration with livestock.
- Economic feasibility of the introduction of sunflower and grain legumes into current farming systems. Increased cropping intensity through the introduction of sorghum and millet crops into improved systems.
- Agro-forestry and management of barani lands for fodder and fuelwood to sustain productivity.
- Improved health and nutrition husbandry for higher economic production of sheep and goats.

Priority 2

- Verification of improved maize technology with farmer participation in maize/livestock systems. Verification of improved wheat technology and the economic benefit over traditional systems.
- Biological and economic assessment of long term crop/livestock systems.
- Improvement of interventions for women in farming systems research project target areas.

Priority 3

- Adjusting cropping patterns according to rainfall probabilities and classification of barani lands by the use of models.
- Economic evaluation of tested herbicides in cropping systems.

- Improvement in the design and statistical analysis of farming systems research projects.
- Identification of nutritional deficiencies and recommendations of fertilizers rates in farming systems research target areas through the use of computer models.

Linkages and relationships. Farming systems research has close collaboration with various programs at the campus of NARC including wheat, maize, fodder, livestock, soil science, social science, agronomy, and plant protection, which work together in the form of a team in the target area. The farming systems research project at NARC is closely linked with provincial institutes through the farming systems research coordinated programme. Annual programmes are planned and reviewed together and frequent visits, monitoring tours, and training programs also help to develop close relationships with provincial and federal centres and institutes involved in agriculture.International agencies like IRRI, CIMMYT, USAID, and others have been very useful for training scientists in the methodology and approach of farming systems research at initial stages of the projects. Farming systems research is done with full participation of the farmers so they know what technologies are being tested. Similarly, extension is involved right from planning stage. Organization of field days, which is also an activity of farming systems research, helps in disseminating the technology developed for the farmers.

Expected accomplishments

- The cropping intensity in the barani tract will be increased by at least 30 percent by introducing oilseed crops and grain legumes.
- The performance of small ruminants (sheep and goats) will be economically improved through verifying and extending health and fodder technologies in order to double twinning percentage.
- Technologies to combat drought including agro-forestry will be tested and recommended according to drought situation by using computer models.
- Collaboration with rural women in farming systems research domains will have expanded with interventions to improve crop, poultry, and livestock technologies, enhancing their incomes and reducing their work loads.
- A systems approach to fertility management will have developed based on calculated plant available moisture.
- Adoption of improved technology through farming systems research and collaboration with extension agencies will have at least doubled net farm income in significant defined barani areas.
- An institutional farming systems research thrust will have evolved through collaborating institutes and agencies in each province that integrates soil, water, crops, and livestock under sound management.

RESOURCE REQUIREMENTS:

AGRICULTURAL ECONOMICS
COMPUTER AND STATISTICS
AGRICULTURAL MACHINERY
FARMING SYSTEMS RESEARCH

AGRICULTURAL ECONOMICS RESEARCH UNIT: Resource Requirements

Project Title	Priority	1988 / 89		1989/90-1991/92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F
Comparative economics of crops and livestock enterprises with a farming system perspective:									
1. Crop livestock interactions and seasonal fodder management.	1	2.0	18500	2.0	129100	2.0	202320	2.0	381780
Setting commodity research priorities for farming systems:									
2. Economics of alternative crop rotations in rainfed area.	1	-	-	1.0	64550	1.0	101160	1.0	127260
Farm productivity, resource availability and constraints:									
3. Production capacity of different farm sizes under differential rates of technological transformation in rainfed conditions.	1	-	-	0.5	32275	0.5	50580	0.5	63628
4. Production technologies and constraints on the adoption of major crops especially in traditional and non traditional oilseeds.	1	-	-	0.5	32275	0.5	50580	0.5	63628
5. Employment and wages of rural women in farm production and processing: impact on productivity due to labour constraints.	1	-	-	-	-	0.5	50580	0.5	63627
6. Intercropping practices.	1	-	-	0.5	32275	-	-	-	-
7. Existing labour types and their functions in agricultural production system.	1	-	-	0.5	32275	0.5	50580	0.5	63627
Farmers' risk management:									
8. Fallow system, land types, and opportunities for increasing cropping intensity.	1	-	-	0.5	32275	0.5	50580	0.5	63630
9. Role of decision analysis in major agricultural businesses.	1	-	-	0.5	32275	0.5	50580	0.5	63630
Soil conservation and moisture management:									
10. Economics of water utilisation on mini dams for crop and other agriculture activities	1	-	-	-	-	-	-	1.0	127255
11. Economics of soil erosion control.	1	-	-	1.0	64550	1.0	101160	1.0	127255

continued

AGRICULTURAL ECONOMICS RESEARCH UNIT (continued)

Project Title	Priority	1988 / 89		1989/90-1991/92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F
Profitability analysis and domestic resource cost of major crops and livestock:									
12. Comparative economics of local and exotic livestock breeds.	1	-	-	-	-	-	-	1.0	127255
13. Economics of commercially produced poultry and inland fisheries.	1	-	-	-	-	1.0	101160	1.0	127255
Returns to investment in agricultural research.	1	-	-	-	-	1.0	101160	2.0	254510
Assessing alternative technologies:									
14. Economics of fertilizers use, reasons for different use levels, and response functions of different farm sizes in various recommendation domains.	2	-	-	0.4	25820	0.4	40464	0.4	50902
15. Economics of alternative pest management and weed control technologies and constraints to their adoption especially at small farms.	2	-	-	0.4	25820	0.4	40464	0.4	50902
16. Economics of tillage operations.	2	-	-	0.4	25820	0.4	40464	0.4	50902
17. Economics of alternative fodder production and more efficient ways of conserving feeds.	2	-	-	0.4	25820	0.4	40464	0.4	50902
18. On-farm testing and evaluation of technologies generated by experiment stations and constraints to their adoption especially by small farms.	2	-	-	0.4	25820	0.4	40464	0.4	50902
Watershed management and agro forestry:									
19. Economics of social forestry.	2	-	-	-	-	0.5	50580	0.5	63630
Economics of soil erosion control.	2	-	-	-	-	0.5	50580	0.5	63630
Evaluation and impact studies.									
20. Dynamics of technological changes in barani areas	2	-	-	0.5	32275	0.3	30348	0.3	38178
21. Economic losses from diseases of livestock as multidisciplinary research strategy.		-	-	0.5	32275	0.3	30348	0.3	38178
22. Inflow of modern agricultural technologies and changing occupational structure of rural areas.		-	-	-	-	0.4	40464	0.4	50904
Farm budget analysis service.									
23. Efficiency and impact of price support and procurement policies on resource allocation, production, income, and employment in rainfed areas.	2	-	-	1.0	64550	2.0	202320	2.0	254510

continued

AGRICULTURAL ECONOMICS RESEARCH UNIT (continued)

Project Title	Priority	1988 / 89		1989/90-1991/92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F
Economic analysis of improved farmers' recommendations.									
24. Cropping systems research: implications for technology design and transfer.	2	-	-	-	-	1.0	101160	1.0	127260
Economic analysis for input supplies.									
25. Emerging occupations in rural areas linking it with commercial agriculture.	3	-	-	-	-	1.0	101160	1.0	127260
26. Production and marketing of livestock fodders and feeds.	3	-	-	-	-	1.0	101160	1.0	127260
Total		2.0	18500	11.0	710050	18.0	1820880	21.0	2799660

BUDGET					
	Staff Costs: Existing (1988/89 + 3%/year)	0	1065060	2731380	4008600
	Additional	0	0	0	0
	Operational Funds	18500	710050	1820920	2672400
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	0	1775100	4552300	6681000

* Number of scientists (BP 17-20) 2 CSO, 4 PSO, 6 SSO, 9 SO. Includes those on study leave or secondment

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

COMPUTER AND STATISTICAL SERVICES: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Optimum plot size and shape of plots for agriculture research on crops of Pakistan.	1	0.5	5000	1.0	8000	1.0	10000	0.5	15000	-	-	-	-
2. Optimum size and number of quadrats for sampling vegetation.	1	0.5	5000	0.5	5000	-	-	-	-	-	-	-	-
3. Factors affecting the comparative efficiency of different types of experimental designs.	1	0.5	7000	-	-	0.5	10000	0.5	9000	1.0	15000	0.5	30000
4. Organize training courses on statistical procedures and computer applications.	1	0.5	6000	0.5	35000	0.5	50000	1.0	60000	1.0	35000	0.5	70000
5. Provide statistical advisory and computing services to NARC scientists.	1	1.0	95000	1.0	143899	1.0	205015	1.0	257024	1	330603	1.0	300000
6. Development of procedures for controlling variability by adjustment of yield of nearest neighbours.	2	-	-	-	-	-	-	-	-	-	-	1.0	65000
7. Clustering methods for grouping plots into uniform blocks.	2	-	-	-	-	-	-	-	-	1.0	25000	1.0	50000
8. Application of non-iterative robust methods for handling problem data.	2	-	-	-	-	-	-	-	-	-	-	1.0	87000
Total		3.0	118000	3.0	191899	3.0	275015	3.0	341024	4.0	405603	5.0	602000

BUDGET		
	Staff Costs: Existing (1988/89 + 3%/year)	439572
	Additional	0
	Operational Funds	121300
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	560572
		452759
		0
		191899
		644658
		466342
		0
		275015
		741356
		480332
		31204
		341024
		852560
		682536
		49421
		405603
		1137560
		999301
		63592
		602609
		1665502

* Number of scientists (BP 17-20) 1 CSO, 1 PSO, 8 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

AGRICULTURAL MACHINERY: Resource Requirements.

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Development of harvesting & threshing equipment for cereals and oilseeds.	1	4.0	300000	4.0	400000	4.0	500000	4.0	500000	4.0	500000	4.0	700000
2. Installation and operation of on-line data acquisition and processing system.	1	4.0	350000	4.0	350000	4.0	400000	4.0	400000	4.0	400000	4.0	600000
3. Development of bulk grain trucks and bulk grain silos with loading/unloading and grain drying.	1	3.0	100000	3.0	250000	3.0	400000	3.0	600000	4.0	650000	5.0	1000000
4. Mechanization impact and machinery demand estimation modelling.	1	3.0	50000	2.0	110000	2.0	100000	2.0	150000	2.0	150000	2.0	300000
5a. Milking equipment for buffaloes promotion of selected hand tools.	1	3.0	150000	2.0	55000	1.0	50000	1.0	50000	1.0	50000	1.0	100000
5b. Animal waste management.	2	1.0	30000	1.0	100000	2.0	125000	2.0	200000	2.0	250000	2.0	350000
5c. Animal housing.	2	-	-	1.0	150000	2.0	150000	2.0	200000	2.0	250000	2.0	350000
6. Design and installation of protected agriculture structures.	1	2.0	42000	2.0	71659	3.0	175566	3.0	411947	3.0	423095	3.0	568593
7. Efficient and improved soil preparation, seeding/planting equipment under Barani and irrigated conditions.	1	2.0	250000	3.0	300000	3.0	200000	2.0	200000	2.0	200000	2.0	300000
Total		22.0	1272000	22.0	1786659	24.0	2100566	23.0	2711947	24.0	2873095	25.0	4268593

BUDGET		1988/89	1989/90	1990/91	1991/92	1992/93-1995/96 Annual average	1996/97-1999/00 Annual average
	Staff Costs: Existing (1988/89 + 3%/year)	2698824	2779789	2863182	2949078	4834759	7078571
	Additional	0	0	287666	378102	350078	450454
	Operational Funds	1272000	1786659	2100566	2711947	2873095	4268593
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	3970824	4566448	5251415	6039127	8057932	11797618

* Number of Scientists (BP 17-20) 3 PSO, 3 SSO, 16 SSO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

FARMING SYSTEMS RESEARCH: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Testing of improved fodder technology in the wheat based barani cropping system and its integration with livestock.	1	1.5	68500	2.0	75000	1.5	83000	1.0	98000	1.0	139000
2. Economic feasibility to the introduction of sunflower and grain legumes into current farming system. Increased cropping intensity through introduction of sorghum and millet crops into improved systems.	1	3.0	123000	2.0	147000	2.0	144000	2.0	166000	1.5	210000
3. Improved health and nutrition husbandry for higher economic production of small ruminants sheep and goats.	1	1.5	98000	1.0	105000	1.0	104000	1.0	117000	1.0	126000
4. Assessment of improved technology to sustain high productivity in crop/livestock systems.	1	1.0	69637	1.0	90780	1.0	151838	1.0	169193	1.0	194286
5. Agro-forestry and management of barani lands for fodder and fuel wood to sustain productivity.	2	1.0	44000	1.0	62000	1.0	97000	1.0	109000	1.0	182000
6. Verification of improved maize technology with farmer participation in maize/livestock systems. Verification of improved wheat technology and the economic benefit over traditional systems.	2	1.0	40000	1.0	55000	1.0	78000	0.5	86000	0.5	99000
7. Improvement intervention for women in FSR project target areas.	2	1.0	55000	1.5	69000	1.0	73000	1.0	114000	1.0	170000
8. Adjusting cropping patterns according to rainfall probabilities and classification of barani lands by the use of models.	3	-	-	0.5	48000	0.5	59000	1.0	70000	1.0	157000

continued

FARMING SYSTEMS RESEARCH (continued)

Project Title	Priority	1988 / 89 Staff*	1988 / 89 Op.F**	1989 / 90 Staff	1989 / 90 Op.F	1990 / 91 Staff	1990 / 91 Op.F	1991 / 92 Staff	1991 / 92 Op.F	1992/93-1995/96 Annual average Staff	1992/93-1995/96 Annual average Op.F	1996/97-1999/00 Annual average Staff	1996/97-1999/00 Annual average Op.F
9. Improvement in design and analysis of FSR projects	3	-	-	-	-	1.0	41000	1.0	61000	1.0	145000	1.0	197000
10. Identification of nutritional deficiencies and recommendations of fertilizers rates in FSR target areas through the use of computer models.	3	-	-	-	-	-	-	0.5	49000	1.0	149000	1.0	213000
Total		10.0	498137	10.0	651780	10.0	830838	10.0	1039193	10.0	1571286	10.0	2014662

BUDGEET								
Staff Costs: Existing (1988/89 + 3%/year)	657691	677422	697745	718677	774218	1419390
Additional	0	0	0	0	0	0
Operational Funds	498137	651780	830838	1039193	1571286	2014662
Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	1155828	1329202	1528583	1757870	2345504	3434052

* Number of programme scientists (BP 17-20) 1 PSO, 4 SSO, 1 SO. In addition 8 scientists from other disciplines/programmes will devote 50 percent of their time to FSR. These scientists will get only operational funds and not salaries from FSR.

**Operational Funds = Total budget less salaries & allowances, rent of residential buildings, pension contribution.

SPECIAL RESEARCH PROGRAMMES

National Coordinated Research Programmes

PARC has developed a number of research programmes in cooperation with provincial institutes, agricultural universities, and federal research institutes. Initially activities were focused on commodities, however related subjects like weed science, soil nutrients, irrigation systems, agro-ecology, agro-forestry, sheep and wool, animal nutrition, meat technology, and livestock cross are now areas of inter-institutional cooperation.

These national coordinated research programmes are led by a coordinator and a coordinating cell. Many of the national coordinators are located at NARC where they also have a research management responsibility. In the past, there has been some confusion about who supervises the coordinators, the NARC DG or the concerned PARC member? Also there has been no distinction in budget regarding NARC research, support, and funding of the coordinating function. It appears from the budget headings that NARC is receiving a disproportionate share of the national coordinated research budget.

The national coordinated research programme organisation and management were reviewed in 1987. The review report contains recommendations on all aspects of the national coordinated research. A summary of those recommendations which pertain to NARC is given below along with explanatory comments.

The coordinator's budget should be separated from the NARC principal investigator's budget.

Currently the budget shows only one figure for NARC, combining funds for NARC's research under the national coordinated programmes and the coordinator's activities which are really PARC functions.

The coordinators should devote a high proportion of their time to the coordinating function.

Coordinators located at NARC are also leaders of NARC's research programme in the commodity to which the national coordinated research pertains. Sometimes the research assignment limits the time available for the coordinating function. (The management review team recommended that the coordinator and the NARC principal investigator be two separate positions.)

National coordinators should be chosen on the basis of their scientific qualifications and located at a research station in an area where that commodity is intensively produced.

Currently nearly all coordinators are PARC employees and most are located at NARC because of perceived difficulties of either obtaining cooperation among provinces with a coordinator who is a member of a provincial research institution, or the logistical problems of locating a PARC employee at a provincial institution.

Coordinators located at NARC should be administratively responsible to the appropriate member of the PARC for matters relating to national coordinated programmes.

Those coordinators who have dual assignments would report to the appropriate member for national coordinated programme matters and to the DG for NARC research matters.

National coordinated programmes should have a strong interdisciplinary focus with a farming systems research perspective.

Currently crop national coordinated programmes have a heavy plant breeding bias. They should focus on doing research to produce improved production technologies. This requires a multidisciplinary team.

National coordinated programmes should be subjected to periodic, rigorous, external reviews to evaluate relevance and quality of research and to recommend improvements.

These reviews would require much effort by the coordinators and would cover much of NARC's research.

International Collaborative Research Programmes

During 1987, financial and technical assistance for combating the problems of low productivity and slow growth of agriculture was given at the national and provincial level by a number of international agencies. CIDA, World Bank, USAID, UNDP/FAO, Swiss Government, ADB, IDRC, ADAB and the Italian Government are currently funding agricultural research projects at a total cost of about Rs.219 million. This reflects not only the enhanced capability of the national system to absorb higher investment in agricultural research, but also the increasing confidence of donors in the beneficiary's commitment to the cause of development through science. An inventory of research programmes in collaboration with international agencies are given below.

PARC International Collaborative Research Programmes

Project	*Total cost Rs. millions*	*Duration*
Pakistan Agricultural Research and Development Project (World Bank)	396.5	1981-82 to June 1988
Barani Agricultural Research and Development Project (CIDA-Canada)	237.2	October 1982 to June 1991
Management of Agricultural Research and Technology (USAID)	447.0	1985-86 to 1989-90
Cooperative Research Program on Productivity, Improvement and Marketing of Potatoes in Pakistan (Swiss Government)	12.7	1982-83 to June 1987
Crop Maximization Programme for Improving Productivity of Wheat, Rice, Maize and Groundnut (Italian Government)	164.5	1984-85 to June 1988
National Chickpea Improvement Project (ADB)	4.4	1983-84 to June 1988
Establishment of National Tea Research Station at Mansehra	20.0	1983-84 to June 1988
Survey of Farm Level Storage Losses in Major Foodgrains (FAO)	4.8	1983-84 to June 1987
Coordinated Research Project on Saline Agriculture	4.9	1987-88 to June 1987
National Outreach Project on Soil Fertility and Fertilizer Use in Pakistan	4.9	1982-83 to June 1987
Pak-German Beekeeping Project(German Government)	2.2	1985-86 to 1987-88
Coordinated Research Project Livestock Feed Resources Nutrition (UNDP)	22.0	1981-82 to June 1987
Coordinated Research Project for Improvement of Sheep and Wool in Pakistan (Australian Govt.)	75.4	1984-85 to 1987-88
Public Law-480 (USDA-Fund)	240.0	-
Food Legumes (Pulses) Improvement Project (IDRC)	3.4	1986-87 to June 1989
Italian Technical Assistance for Cultivation of Fruits, Vegetables and Olives (Italian Government)	62.5	1986-87 to June 1991

Source: PARC Annual Report 1987

Barani Agricultural Research and Development

To raise the standard of living of the rural population and to ensure sound and effective use of scarce agricultural resources, it is necessary to increase the productivity of agriculture lands through more intensive farming, better crop varieties, and better cultural practices. With this base, Pakistan will be able to develop and test, on an on-going basis, agronomic packages for application in various barani regions directed towards raising agricultural productivity and reducing risk of crop failure. It is not anticipated that benefits from the BARD project will be immediately available to the majority of the population. However, the research findings will help develop appropriate production technology to make the country self-sufficient in agricultural products. Specifically the major problems are:

- Conservation of soil and water. Rainfall is unpredictable and erratic.
- Low productivity of barani lands, resulting from inadequate moisture and low fertility, inappropriate tillage, seedbed preparation, sowing, harvesting, and threshing equipment, and shortage of labour.
- Little research on cultivars which could make the best of the prevailing environment.
- Inadequate marketing mechanisms for barani area crops.
- Lack of alternative means of livelihood and lack of appropriate farming systems.
- Scanty infrastructure for procurement of inputs, i.e.,credit, farm machinery, crop chemicals, seed, and supplemental feed for animals, etc.

Goals and objectives. The principal aims of the Barani Agricultural Research and Development project are:

- To establish a well-coordinated and integrated programme for agricultural research applicable to barani areas of Pakistan.
- To introduce high yielding varieties and production techniques suited to the socio-economic conditions and the varied climatic pattern and farming systems of barani areas.
- To establish operational research units that serve to advance technology as well as to demonstrate practical application of improved practices generated at NARC and provincial institutes.
- To estimate the impact of research on capturing some of the potential for increased food production in various barani areas.
- To disseminate proven packages of agronomic technology to all institutions and agencies responsible for increasing agricultural production in the barani areas.

Mandate. The Barani Agricultural Research and Development (BARD) project involves the basic theme of the CAREPLANS adopted by the PARC, i.e., the research involves both the doers of research and end users of research (farmers). The plan of work, therefore, involves the development of packages of technologies on farming systems, range management, and agricultural machinery prototypes at NARC and provincial research institutes including the Barani Agriculture Research Institute, Chakwal. The packages of technologies thus developed will be tried on selected farmers' fields at various locations in all the provinces. As proven packages of technology are developed, they will be handed over to the provincial extension departments for transfer to the field.

Current programme. The project has an office, laboratory, and field facilities at NARC. Operational research is conducted in three provinces, but with a concentration in the barani lands of Punjab and NWFP. The research programme is being carried out under the following components: A farming systems research team is working on a broad range of biological, physical,

and socio-economic questions that affect rainfed agriculture. Another team of researchers is working on the introduction of Canadian rapeseed varieties into rainfed cropping systems. Suitable agricultural machinery for the agronomic technology packages is being identified and produced.

Linkages and relationships. On campus, the BARD project will require participation from oilseeds, soil fertility, plant protection, animal nutrition, farm mechanization, and social sciences division. The BARD project collaborates with the departments of agriculture in all four provinces and with various universities. It also collaborates with other Pakistani centres where site-specific dryland research is in progress which relates to BARD mandate. BARD project will receive and exchange the germplasm and genetic material with ICRISAT, ICARDA, CIDA, USAID, FAO, and other international centres. The imported material will be evaluated and screened at NARC. As the BARD project generates improved technology in various disciplines from its base at NARC, the operational research sites will provide an important means by which farmers may validate it in their dryland farming systems.

4
Research Management

BACKGROUND

NARC Organization and Management

The current organization of NARC is the result of rapid growth with too little planning. As a result, the organization is sometimes illogical and does not conform to sound management principles. Fortunately, a recent management review of NARC has provided guidelines for a reorganization that will, if adopted, significantly improve the organization and management of the institution (Figure 4).

The centre is currently headed by a director general, assisted by a deputy director general, with a management board and a research committee to assist in the administration. However, the latter units have not been functioning effectively. More than 20 research, technical support, and administrative units report directly to the DG and DDG. In addition there are 12 coordinators of national coordinated research programmes located at NARC who have national responsibilities as well as their NARC research assignments. Complicating the management structure further are multidisciplinary development projects located at NARC. The relationship of the PARC chairman, members, and other officers to the DG and NARC staff and NARC's research programmes is not clearly understood, sometimes leading to confused management procedures. Finally, the make-up of some of the research sub-units has not been carefully thought through, resulting in illogical groupings. For example there is a plant virology unit separate from plant pathology, and weed science forms a part of the entomology unit, a sub-unit of central laboratories.

Analysis of NARC Questionnaire and Report

A questionnaire distributed early in the master planning process revealed that scientists at NARC perceived a number of plusses and minuses in the management at the centre. For example 97% of them believed that scientists should be allowed to put more effort into determining what research is conducted, and 70% felt that procurement procedures and practices were inadequate. The following is a summary of the most decisive results from the questionnaire:

Statement	*Agree*	*Disagree*	*Undecided*
Lack of reward for performance retards achievement of research excellence.	64	23	14
Scientists should put more effort into seeking what research be conducted	97	2	2
Internal research reviews encourage scientists to keep research content abreast.	91	4	4

(Cont'd)

(Cont'd)

Field experimentation and farm operations are satisfactory/well organized.	71	16	14
In general laboratories are adequate for research.	74	5	11
The library resources and services are adequate for research.	57	37	7
Procurement procedures and practices ensure supplies and equipment on time.	19	70	12
Operational funds for research are adequate and provided on time.	34	50	15
My research is successfully integrated and coordinated with other institution scientists.	76	11	14
Staff members at my level have an adequate voice in planning and conducting research.	59	29	12
Unit committees, meetings and other means provide for adequate communication.	82	6	12
Opportunity for advancement at NARC is an incentive for me to do excellent research.	81	6	12

Synopsis of NARC Review Team Report

The management of NARC was thoroughly reviewed in February and March 1988 by a five-member review team. The recommendations of this team, if adopted by NARC, will significantly alter and improve the institution's organizational pattern and administrative procedures. These recommendations are currently under study by the senior management of PARC and NARC. While it is clear that many of the recommendations will be adopted and implemented at NARC, none have been at this date. Consequently, for the purposes of the NARC Master Plan, the main recommendations of the NARC management review team are summarized below.

For convenience the teams' 28 recommendations have been grouped under four headings: policy, organization, procedures, and training. Each recommendation is stated in brief, and a few explanatory remarks are given. The original recommendation number given by the review team is retained.

POLICY

1: *The PARC Board of Governors should approve a new, brief formulation of the NARC mandate and publicize it widely.*

This was thought necessary because multiple statements have appeared in PARC and NARC. The team noted that three main points are common in existing statements: (1) long-range and basic, but mission-oriented research, (2) emphasis on farming systems research, (3) provision of specific support services to the national research system.

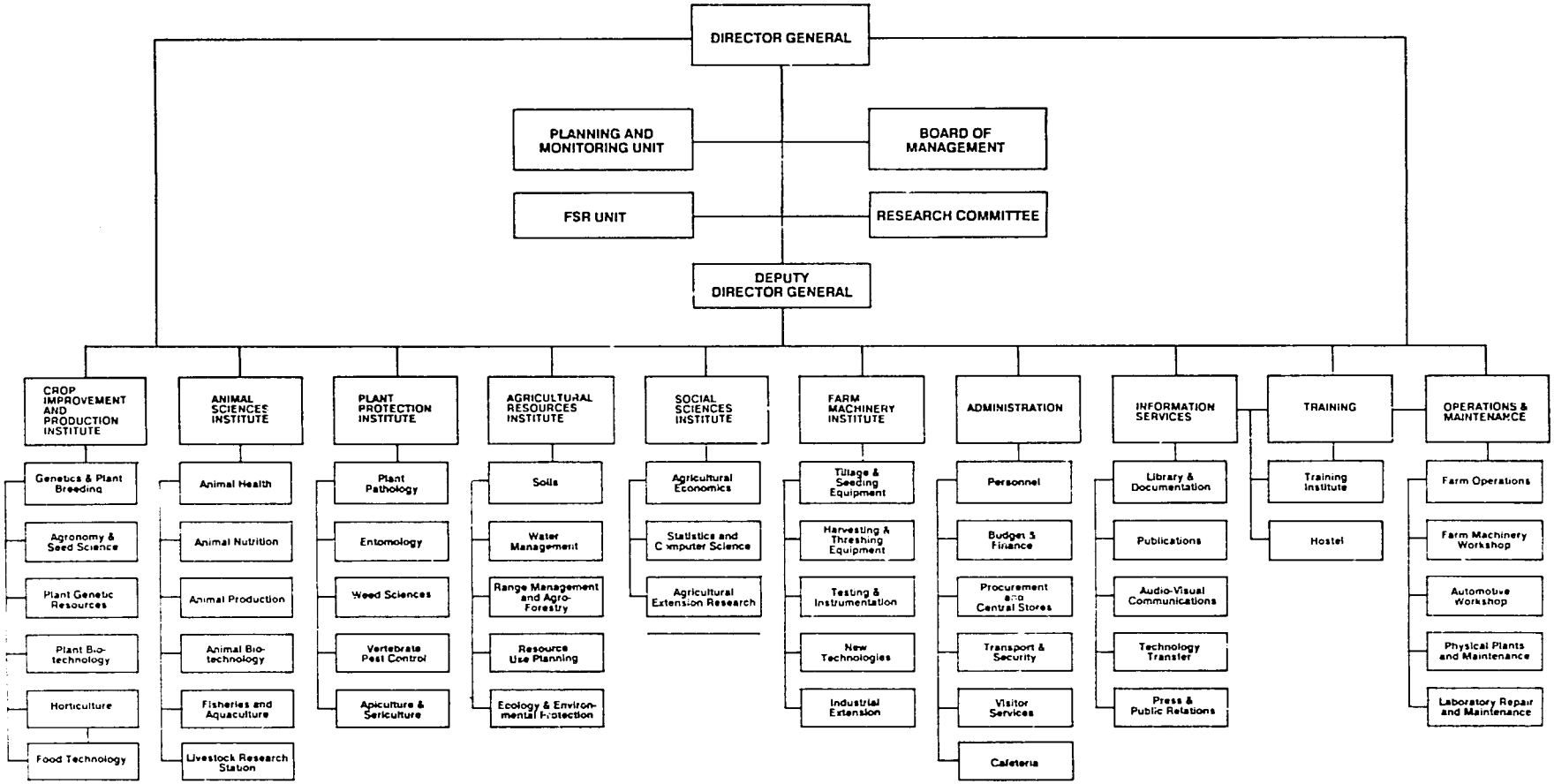
2, 3, 16: *NARC should be allowed to plan its research programs, under guidelines set by PARC, and to manage these activities without direct guidance from PARC members or other PARC officers.*

The review team perceived that PARC's senior staff currently are actively managing research activities at NARC thus short-circuiting the DG and DDG. They recommend that PARC should set policy, hel make research plans, and set budget, but PARC should not be involved in directing th earch.

21: *A policy to utilize income from NARC activities should be developed.*

The team said that NARC should be encouraged to generate income, without of course interfering with its research role, and that all income generated by NARC would be utilized by NARC.

Figure 4. Proposed organizational chart for NARC



EXPLANATION OF THE PROPOSED ORGANIZATIONAL CHART

The Director General NARC is the Chairman of the Board of Management and the Research Committee. Both the Planning and Monitoring Unit and the Farming Systems Research Unit are directly responsible to the Director General. Deputy Director General provides coordination among the six institutes namely: (1) Crop Improvement and Production Institute; (2) Animal Sciences Institute; (3) Plant Protection Institute; (4) Agricultural Resources Institute; (5) Social Sciences Institute; and (6) Farm Machinery Institute.

C.P.I. CROP IMPROVEMENT AND PRODUCTION INSTITUTE
Genetics and Plant Breeding
Agronomy and Seed Science
Plant Genetic Resources
Plant Biotechnology
Horticulture
Food Technology

A.S.I. ANIMAL SCIENCES INSTITUTE
Animal Health
Animal Nutrition
Animal Production
Animal Biotechnology
Fisheries and Aquaculture
Livestock Research Station

P.P.I. PLANT PROTECTION INSTITUTE
Plant Pathology
Entomology
Weed Sciences
Vertebrate Pest Control
Apiculture and Sericulture

A.R.I. AGRICULTURAL RESOURCES INSTITUTE
Soils (Soil Fertility; Plant Nutrition; Soil Chemistry & Mineralogy; Soil Physics; Soil Biology; Stress Physiology)
Water Management (Soil & Water Conservation; Irrigation Systems and Management; Agricultural Meteorology)
Range Management and Agro-forestry
Resource Use Planning
Ecology and Environmental Protection

S.S.I. SOCIAL SCIENCES INSTITUTE
Agricultural Economics
Statistics and Computer Science
Agricultural Extension Research

F.M.I. FARM MACHINERY INSTITUTE
Tillage and Seeding Equipment
Harvesting and Threshing Equipment
Testing and Instrumentation
New Technologies
Industrial Extension

ADM. ADMINISTRATION
Personnel
Budget and Finance
Procurement and Central Stores
Transport and Security
Visitor Services
Cafeteria

I.S. INFORMATION SERVICES
Library and Documentation
Publications
Audio-visual Communications
Technology Transfer
Press and Public Relations

TRG. TRAINING
Training Institute
Hostel

O&M OPERATIONS AND MAINTENANCE
Farm Operations
Farm Machinery Workshop
Automotive Workshop
Physical Plants and Maintenance
Laboratory Repair and Maintenance

23: *NARC's internal and external linkages should be strengthened.*

Internal linkages with universities, agricultural research institutes, and extension are emphasized.

ORGANIZATION

6: *The DG should be assisted by at least two full-time DDG's one for research, and one for administration and technical support services.*

Crop production, crop protection, farm machinery, natural resources, central laboratories unit, and social science would report to DDG (Research). DDG (ATS) would supervise Director Administration, Director Finance, Director Scientific Information. (Note: The review team did not mention the Director Technology Transfer in their report).

7: *The Board of Management should be re-constituted and should approve all research projects and programmes. The research committee should report to the Board of Management.*

The review team noted that the board essentially does not function now. They recommend that the board should be made into an effective instrument for planning, coordinating, monitoring, and evaluating all activities at NARC.

8: *A planning and monitoring cell should be created and attached to the DG to service the Board of Management.*

This cell, headed by a director, would function in a staff role to the DG and Board of Management.

9: *An administrative committee should be set up, also reporting to the Board of Management for purely administrative matters.*

This committee would be chaired by the DDG (Administration and Technical Support Services).

10, 17: *The NARC components of the national coordinated research projects should be under the control of the DDG, and the positions of national coordinator and NARC principal investigator should be two distinct posts.*

Currently there is considerable confusion regarding the role of NARC staff who function both as coordinators of national coordinated programmes and as principal investigators for the NARC research in national coordinated programmes. These recommendations would provide separate posts for these jobs and put the NARC principal investigator squarely under the direction of the DG.

11: *The institutes at NARC should be renamed departments and each should be headed by a full-time director.*

The name of department would help in removing any illusion or expectation of autonomy.

12: *A crop production department, under a director, should be established.*

This department would include the current NARC components of the 12 national coordinated programmes on crops, the plant introduction centre, the plant genetics resources unit, weed science, plant physiology, seed technology, horticulture, biochemistry, cytogenetics, and tissue culture.

13: *A plant protection department, under a director, should be established.*

This department would include the current crop diseases research institute plus the virology, nematology, microbiology, and entomology units.

14: *The revised structure of the scientific units should comprise five major departments (plant production, plant protection, animal sciences, farm machinery, and natural resources), the central laboratories, and the social sciences unit.*

All these would report to the DDG (Research). The social sciences unit is considered too small to constitute a department at this time. Central laboratories would comprise food technology and nutrition, nutritional biochemistry, food quality, oilseed quality, and the electron microscopy unit.

15: *An advisory committee should be set up for the farm machinery department.*

This committee's membership would be drawn from provincial and federal agencies and major private companies.

18: *All disciplinary specialists should be regarded as members of the appropriate department or discipline group.*

This recommendation follows the concept that scientists in various disciplines need to be associated with their scientific peers. The team visualized that scientists would have offices together in departments where they would come into day-to-day professional contact, attend seminars, and enter into departmental discussion. Their research assignments, however, would be funded and directed by the interdisciplinary research project of which they are a part.

PROCEDURES

20: *Administrative and financial support services should be streamlined.*

Recommendations were made for a number of changes, including broader power to the DG for budgetary matters, utilization of income, training for administrative and financial staff, and the creation of a new position of director of finance.

22: *Other support services should be streamlined.*

This recommendation pertains to services that are exclusively for NARC and those services having a national application. NARC services are transport, procurement, workshop, stores, and farm operations. Nationally applied services are scientific information, laboratory analysis, gene bank, training, and audio visual communications.

27: *Research leadership needs to be developed.*

The review team proposed that each principal investigator at NARC should help in developing the research capabilities of his staff and suggested eight activities for this purpose.

28: *This review should be monitored by reassembling the panel.*

The review team would reassemble for 2 to 3 days at the end of a year to assess what changes had been made.

TRAINING

24: *Establish pre-service and in-service training.*

A 1-year, pre-service training staff for new courses with considerable emphasis on entrants and a variety of in-service training research management activities are recommended. The team also advocates using Pakistani management training institutions.

25: *The training department needs a core staff with some expertise in management.*

A few core staff for the planning, development, management, and evaluation of the

courses are recommended, and some professional management expertise for training purposes is needed.

26: *The most senior managers should be helped by training to set a good example to their juniors.*

This is a recommendation to offer training in management subjects to scientific personnel to enable them to become better managers of research.

TECHNICAL MANAGEMENT

Research Programmes and Project Development

Prior to the development of a national commission on agriculture, PARC had set 10 subject-matter areas to which different programmes are linked:

1. Crop Production
2. Crop Protection
3. Livestock Production
4. Fisheries Development
5. Forest Development
6. Watersheds and Rangelands
7. Water and Soil Conservation
8. Socio Economics
9. Policy and Marketing
10. General Priorities (Communication, Publications, research support services etc.)

In each category, goals and objectives were published in a report "Priorities in Agriculture", prepared by 24 subject-matter working committees. The research goals are prioritized within each area by FAO-sponsored committees involving 300 people from 500 research establishments in Pakistan.

Research programmes. A research programme or a project is developed in the light of goals and objectives. At NARC, there are 51 programmes being executed (Annex II). Most of these involve both basic and applied aspects of research and therefore have their own laboratories established at the complex. Those programmes engaged in adaptive research may share laboratory facilities with others in an interdisciplinary approach. The distribution of projects among the various divisions reflects emphasis on the crop sector: crop sciences, 44%; natural sciences, 28%; animal sciences, 16%; social sciences, 5%; and other special programmes (FMI, CMP, BARD, and MART), 7%.

Project development. For each independent or coordinated project, the following information must be assembled before it is formulated:

1. Title
2. Objectives
3. Present and previous work/background (Review of literature)
4. Methodology/approach
5. Resources need
6. Personnel
7. Cooperators
8. Institutional units involved
9. Any other information needed to evaluate the project

Multidisciplinary Technical Working Groups

Projects prepared by the individual expert or a group of experts or a group of scientists are presented to a technical working group (TWG). There are 11 TWGs deputed for different working sectors (Annex III). Each TWG has 8 to 10 members and a convenor. The members are qualified by their background in the subject-matter area of the TWG. These committees critically review the projects and the field and laboratory experiments to ensure that:

- the planned experiment/project does waste resources.
- it is not aimless work.
- efforts are restricted to achieve the stipulated objectives of NARC or the task is compatible to with NARC mandate.

After thorough screening, a TWG can decide to:

- Approve as such for further action of the research committee.
- Approve with some alteration/improvements and then send onward to the research committee.
- Defer or drop.

The approved version of the experiment or project is passed to the research committee for further discussion. The research committee headed by the director general, NARC, is comprise of convenors of various TWGs and some selected subject specialists. This committee assures that no overlap occurs between different programmes and determines if some kind of collaboration could be possible. After the approval of this body, authorization is given for farm services to prepare land for experiments and for the laboratory in-charge to provide facilities for the implementation of the planned experiments.

Government-financed projects. In large projects or schemes involving substantial Government of Pakistan funds, the research proposals are submitted on prescribed forms (PC-I), and screened by the technical committee at PARC. This body is headed by the technical member of the respective division and includes members from PARC/NARC and the provinces. Approved projects follow regular planning procedures and are submitted for the approval of the Secretary, Research Division, Ministry of Food and Agriculture, and then examined by the central development working party.

After approval, if the amount is over Rs.20 million, the proposal is sent to the economic committee of the National Economic Council. Once a project is approved, yearly allocations are made by the Government in its annual budget. These allocations are released to PARC in monthly installments. PARC, in turn, releases the funds to the projects in quarterly installments. The projects submit quarterly reports which are scrutinized by the accounts department of the PARC. Government auditors examine the accounts of these funds annually.

PL-480 Funds. The PL-480 financed projects are governed by the U.S. Foreign Agricultural Research Grant Program. These funds are earmarked after a project has been approved under procedures laid down by the U.S. Department of Agriculture.

Other funds. The main source of other funds is USAID, which sponsors the project "Strengthening of Agricultural Research Capabilities in Pakistan". According to the established procedures of the Government of Pakistan, all foreign aid is negotiated by the Economic Affairs Division and passed to the intended beneficiary through the budgetary mechanism so that the funds are reflected in the federal government accounts. In accordance with the Government instructions in force at present, the aid received from USAID is negotiated by the Economic Affairs Division and, after the agreement for the loan or grant is signed, the cheque is issued by USAID in the name of Secretary, Ministry of Finance. The Finance Division then sends the cheque to State Bank of Pakistan for crediting to Federal Government Account No.1 (Non-Food)

with advice to the agriculture ministry to place the amount at the disposal of PARC. Necessary administrative sanction for the release of a specified amount is then issued by the Ministry of Food and Agriculture to the AGPR Islamabad/Rawalpindi, which places the funds in the PARC account with the Government Treasury/Bank. When the funds are in the account of PARC, required amounts withdrawn or utilized after receipt of proper expenditure sanction issued by the competent authority of PARC.

Research Monitoring and Evaluation

The planning research monitoring cell (PRMC) of NARC is headed by the director general, NARC, and is composed of the deputy director and his staff.

After the approval of the research committee, the NARC research coordination and monitoring cell (RCMC) not only helps implement the decisions of research committee, but also monitors to see that progress is smooth and that scientific efforts are not blocked.

The standing sub-committee of the research committee visits with working scientists periodically to assess and review progress and constraints. The interim required corrective steps are taken by NARC management immediately. RCMC also publishes the titles and objectives of the various experiments, the executing personnel, and the location for the benefit of research administration, policy makers, planners and scientists in institutes throughout the country.

Programme and project performance indicators have been developed:

1. Developed work plans which address the identified research objectives and thrusts.
2. Evidence of progress in pursuing research thrusts which address national production, processing, and marketing goals.
3. A developed and conducive research system with an environment which stimulates creative research and conditions new scientists into the national agriculture research system.
4. Established linkages with both the national agricultural research system components and the international research community.
5. Improved technology generated through basic and applied research developed by interdisciplinary teams and consistent with a farming system approach.
6. Effective packaging of research results, successful on-farm testing, and transfer of research technology appropriate to different agro-ecological zones.
7. Development of effective training and other support services readily available to the national agricultural research system participants.
8. Effective research management system and organisational infrastructure that serves as a model for others.
9. An established, sound, planning, monitoring and evaluation capability for research, training, outreach and administration.

In 1987, the chairman of PARC initiated an internal review of each programme. Minutes for each unit were separately issued for further improvement.

Publications

The objectives of the publication unit are:

- To undertake preparation, publication and dissemination of research and popular style journals, annual reports, seminar proceedings, crop production bulletins, leaflets, etc.

- To publish textbooks and monographs on agricultural topics for various categories of users.
- To maintain a distribution system so that PARC publications reach all categories of people linked with agricultural sector.
- To arrange special PARC stalls at agricultural exhibitions held around the country.

Facilities. The directorate has in-house facilities to prepare camera-ready material for printing. These include an IBM Mag Card Composer, Urdu Calligraphy, art work, designing, layout, page making, etc.

Current programme. The publication unit publishes periodicals, textbooks, monographs, technical reports, proceedings of seminars, symposia, workshops, and extension bulletins in Urdu. It prepares and maintains up-to-date distribution lists, designs, composes, and prints introductory brochures and title covers, and prepares banners for PARC sponsored symposia and workshops and arranges PARC stalls, at agricultural exhibitions.

Six periodicals are being produced by the directorate of publications: Annual Report, Pakistan Journal of Agricultural Research (quarterly), Progressive Farming (bimonthly), PARC News (monthly) and PARC Activities Bulletin (weekly). Text books and monographs on various topics of agriculture are also printed.

Technology Transfer

The dissemination of research knowledge and the application of that knowledge to practical farm problems is one of the chief missions of the agricultural extension system. Because of rapidly occurring changes in the national agricultural arena, there is a growing concern that the extension services do not measure up to farmer needs.

In reviewing the agricultural extension services in Pakistan, the National Commission on Agriculture recommended that the extension system and its mechanics should be modified and improved to make the services more efficient and their information delivery system more effective. To make more informed policy decisions, top-level extension managers and research administrators require more empirical information on the agricultural extension systems in the country.

At present, there is no agency responsible for conducting research on agricultural extension issues. The extension research programme a newly introduced unit in the Social Sciences Division, intends to pursue the research in the various fields of agricultural extension, which have been badly neglected in the past. Such research would not only examine the constraints and impediments which impinge on the extension system's performance, but also suggest ways to reach more people with educational programmes. Thus, the improved functioning of the system would enable extension agencies to disseminate, and encourage the application of, research-generated agricultural knowledge and leadership techniques to individuals, families, and farm communities.

Goals and objectives. The principal aims of agricultural extension research are:

- To develop, test, and suggest improved methodologies and models for extension systems in Pakistan.
- To study the impact that the provincial extension services have on agricultural productivity.
- To strengthen the capabilities of extension and rural development institutions by carrying out research on various issues involved at local, provincial, and national levels.

- To cooperate with the agencies and institutions of local, provincial, and federal governments and private sectors in the development and conduct of educational and information research programmes.
- To develop a national extension database.
- To assist in the development and understanding of national and international issues involved in the transfer of agricultural technology.

Mandate. Research on agricultural extension systems in Pakistan is the general mandate of the extension research programme but the central thrust of the research programme is to orchestrate efficient ways of transmitting agriculture-related information to consumers, government functionaries, and policy makers to enhance their understanding of agriculture and policy needs. The proposed research efforts would not only span the whole country but would actively involve the extension specialists doing research and teaching in the universities. This will strengthen linkages among the provincial extension services, academic institutions, and federal research and extension agencies.

Current programme. The extension research programme is a newly established programme at the headquarters of PARC. A collaborative study of research-extension-farmer linkages in Pakistan has been proposed and there are a few more research proposals in the pipeline. Management of an agricultural extension information data bank is another vital feature of the unit. The extension research programme is also working to develop links with extension networks around the globe.

Proposed programme

Priority 1

- A collaborative study of research-extension-farmer linkages in Pakistan.
- Improved functioning of the agricultural extension training institutions in Pakistan.

Priority 2

- Training needs of extension agents as perceived by them.
- Role of rural youth in reviving national agricultural growth.
- Improved strategies of information delivery in agricultural extension.
- General evaluation of extension systems to modify their organisation, their focus, and their use of resources.

Linkages and relationships. The extension research programme will require a varying degree of involvement with and support of the following programmes: agricultural economics research units at NARC, Faisalabad, NWFP, and Baluchistan; technology transfer unit, NARC; farming systems research group at NARC; all commodity programmes at NARC. Collaborative activities will also be conducted with University of Agriculture, Faisalabad; Agricultural University, NWFP; Sind Agricultural University; Agricultural College, Quetta; and Barani Agriculture College; as well as with Pakistan Rural Development Academy, Sind Development Studies Center, Institute of Development Studies, Peshawar University, Pakistan Institute of Development Economics, Allama Iqbal Open University, and National Centre for Rural Development, Islamabad.

The research findings will be published in national and international journals for wider dissemination and practical use. The research reports will be circulated among the concerned agencies for better and more uniform future planning, coordination, and cohesive action. The Extension Research Programme database will provide information on technical manpower, financial allocations, and organizational structures, and on an array of other issues of the extension services both at provincial as well as national levels.

Training, seminars, and workshops etc., will be the chief apparatuses to be employed to diffuse research findings to the extension specialists, researchers, and farmers. Training of extension agents and researchers on communication, project planning, extension methodologies, monitoring and evaluation, and adoption behaviour of farmers also occupies a high priority in Extension Research Programme.

Extension Activity District, Islamabad

Mandate. To link NARC scientists and farmers of Islamabad Capital Territory for the promotion and development of agriculture.

Objectives and goals. The principal aims are:

- To develop a reproducible agricultural extension model suitable for the area.
- To narrow the gap between potential production and actual production of field crops and to introduce high value crops on farmers' fields.
- To enhance fruit and vegetable production for home consumption and sale.
- To streamline the supply of farm inputs (seed, fertilizer, pesticides, credit, and farm machinery) and marketing of farm surplus.
- To encourage afforestation including block and linear planting, farm forestry, and community planting.
- To conserve soil and moisture, harness the water runoff, and develop groundwater resources for irrigation purposes.
- To increase fodder and forage production and to improve the rangelands.
- To optimize meat, milk, and egg production by developing proper measures in livestock, poultry, and fish production.

Current programme. The main efforts are, in agriculture, optimisation of crop production (wheat, maize, oilseed, pulses, and fodder crops) and fruit and vegetable production and introduction of other high value crops; in soil and water conservation, tree plantation, integrated land use practices, harnessing of surface water; in livestock and dairy development, disease control, improved breeding and reproduction, and animal feed and feeding; in fisheries, fish production in community ponds and reservoirs; in forest and rangelands, afforestation including block and linear plantation, farm forestry and community planting, and range improvement and management in blocks.

HUMAN MANAGEMENT

Rank and Salary Structure

Three schedules developed by the PARC executive committee November 1983 revised in March 1984, define salaries for various ranks. The category and rank designation are shown below. Academic qualification and years of experience provide the criteria by which rank is established.

Category and designation	*Basic scale*	*Pay scale (1988)*
Crops sciences, Natural Resources, Animal Sciences, Statistics and Agricultural Economics		
Chief Scientist	21	5400-290-7740
Chief Scientific Officer	20	4900-235-6700
Principal Scientific Officer	19	4130-205-5770
Senior Scientific Officer	18	2710-195-4660

(Cont'd)

(Cont'd)

Scientific Officer	17	2065-155-3925
Assistant Scientific Officer	16	1330-105-2925
Agricultural Engineers		
Senior Principal Engineer	20	4900-235-6700
Principal Engineer	19	4130-205-5770
Senior Engineer	18	2710-195-4660
Assistant Engineers	17	2065-155-3925
Scientific information Documentation and Library		
Principal Information officer	19	4130-205-5770
Principal Documentation Officer		
Principal Editor		
Principal Librarian		
Senior Information Officer,	18	2710-195-4660
Senior Documentation Officer,		
Senior Editor, Senior Librarian		
Information Officer	17	2065-155-3925
Documentation Officer		
Editor, Librarian		
Assistant Information Officer	16	1330-105-2925
Assistant Documentation Officer		
Assistant Editor		

Mode of Recruitment for Research Posts

The policy for recruitment is as follows:

1. Selection will be made through public notice and a competitive examination.
2. Those candidates with above-average marks will be called for interview by a high-level selection board.
3. For grade 17 posts, candidates up to 25 years old are eligible to appear in the competition.
4. Scientists recruited for talent pool will attend an orientation course.

Conditions for Retention in Service (Emoluments)

1. Initial pay of new entrants at higher stage on the basis of academic attainments will be admissible for posts in scientific and technical services.
2. Scientists, etc. who possess a Ph.D. or D.Sc. degree from a foreign university will be allowed 6 advance increments on entry in service in BPS-17.
3. Scientists, etc. who posses a Ph.D. or M. Phil from a university in Pakistan will be allowed four advance increments on induction in service in BPS-17.
4. Scientists, etc. who while in service in BPS-17 obtain a Ph.D. or D.Sc from a foreign university will be allowed four advance increments.
5. Scientists, etc. who possess, M.Sc., or equivalent from a foreign university will receive four advance increments on induction in service in BPS-17.
6. Scientists, etc. who while in service in BPS-17 obtain Ph.D. or M.Phil from a university will receive two advance increments.
7. Scientists, etc. who while in service in BPS-17 obtain M.Sc or equivalent from a foreign university will receive two advance increments.
8. Scientists, etc. who possess foreign qualification such as Ph.D. on induction in service in BPS-17 will receive advance increments only for such higher qualifications at M.Sc level above and advance increments or basis of

academic attainments up to M.Sc. level will not be admissible.

9. Initial pay of scientists, etc. having research or practical experience in addition to minimum qualifications prescribed may be fined at higher stage.

Evaluation Criteria for Scientists Proposed

The progress of individual or team scientists may be evaluated against the following:

1. *Degree to which the researcher has achieved the objective(s) of his/her research project.*

   This assumes that the researcher is already working on a project with clear objectives or that the project has a detailed work plan with each major activity identified to be performed within a set timeframe.

2. *Degree to which the researcher has made an original contribution in generating new knowledge, technology, or methodology.*

   This implies that the researcher is clearly building upon past experience and scientific literature while generating new and original information.

3. *Degree to which the researcher exhibits initiative and conducts his/her project with minimum supervision.*

   This puts a premium on the researcher's ability to organize and follow through on his own. It assumes that the scientist thinks for himself yet respects the opinions of peers.

4. *Degree to which the research on complex agricultural problems demands good interdisciplinary team effort.*

   This assumes that an effective scientist does not work in isolation, but is a valuable member of a research team whose efforts are synergistic for team achievement.

5. *Degree to which the quality of research results has been recognized by peers and other knowledgeable persons.*

   This assumes that the researcher is in touch with other scientists in his/her area and may be measured in terms of participation in conference, citations in other publications, interaction with scientists from other countries, etc.

6. *Degree of acquired success in transfer of his/her work through publications and other appropriate mechanisms.*

   The quantity of publications is less important than their quality and impact especially on the rural community. Mass communication such as radio and television should be considered.

FINANCIAL MANAGEMENT

Adequate Long-term Financial Support

PARC's source of funding is rupee grants from the Government for current expenditure as well as development expenditure and foreign exchange received as aid from international organizations and foreign governments as part of the annual development programme prepared and approved by the Government of Pakistan.

The current expenditure budget is almost entirely met from Government resources; except for a significant amount of income from other sources such as sale of crops. The major portion of the current expenditure budget of PARC is allocated to NARC. During the 1988-89 financial year, the budget allocation to NARC was Rs. 48.3 million, which is 45% of PARC's total budget. These funds were allocated to various programmes based on their needs and priorities determined by

the technical divisions and committees. The development budget is also sanctioned by the Government according to priorities given in the national 5-year development plan and the overall resource position for the year.

Although there has been a marginal annual increase in the current expenditure budget over the past few years, the amount available for commodities and services has been falling sharply because a growing portion of the total budget allocation has been appropriated to meet significant increases in salaries and allowances. For this reason, the availability of research funds for scientists during the last 4 years has decreased 50%.

As the funding of PARC is totally based on Government grants, funds to NARC for both current and development expenditure will be allocated according to the budget sanctioned by the Government every year. However, NARC, being the major centre of PARC for agricultural research, will continue to receive the maximum funds which are available for carrying out its assigned activities for improvement and development of the agricultural research system.

Apart from the allocation by the Government, efforts will be made to generate income by growing and selling plants, crops, and other agricultural produce on non-experimental land, using part of additional funds for research and development with the approval of Government.

Computerised Accounting System

The work of computerisation and implementation of the accounting system according to the manual prepared by the financial management consultant is being implemented. A network microcomputer system with four work stations is installed and the following application systems are being computerised: general ledger, inventory control, procurements and accounts payable, MIS reporting, project accounting, fixed assets accounting, and payroll accounting.

Because the major portion of PARC budget is spent at NARC and the number of transactions is large, it is essential to have the accounting system fully computerised and needs of NARC, both for hardware and the software, fully met. This needs to be done on priority basis to increase the efficiency of the financial management system. The number of work stations at PARC might be increased to seven with the additional three stations at NARC linked to PARC through a network. If a link is not possible, then three network stations might be set up at NARC with similar hardware so that the flow of information can be effected through exchange of diskettes, etc.

Delegation of Financial Authority

Certain financial powers have been delegated to the director general, directors, P.I.'s, and coordinators at NARC to conduct research. However, their administrative and financial powers need to be enhanced. Increased autonomy is planned. All directors, P.I.'s, and coordinators should be well aware of the financial rules and procedures and vigilantly exercise delegated powers for effective financial control and achievement of the desired objectives.

PERSONNEL MANAGEMENT

Matters pertaining to recruitment, transfer, leave, promotion, and retirement etc., of employees in BPS-15 and below, are handled locally at NARC. The cases of officials in BPS-16 and above are initiated and sent to PARC headquarters which deals with appointments, transfers, promotions, etc. The personnel records of employees BPS-1 to 15 are also maintained at NARC.

The number of scientific and supporting manpower in different grades working at NARC is

BPS-1 to 15	819
BPS-16 to 21	348

The staff in the administration branch in NARC is not adequate to cope with the work relating to personnel management. There is, therefore, need to strengthen the administration wing by providing additional posts of one assistant director (administration), one assistant administrative office, one stenotypist, two office assistants, two junior assistants (BPS-07) and two junior assistants (BPS-05). Computerisation of records and operations in administration will improve the efficiency and services of this unit. Training of staff in use of computers will also be needed.

5
Support Services

Audio-Visual Communications

A considerable amount of improved agricultural technologies is being generated in Pakistan by research organizations including NARC. However information concerning these technologies must be disseminated in ways which make it understood and acceptable to target audiences or client groups. Appreciating the role of effective communications, PARC included information transfer as one of the five major components of MART project.

Objectives and goals. The main purposes of information transfer component are:

- To make research results more readily available to the potential end-users.
- To disseminate the information in ways which respond to the needs of client groups and which ensure that the information will be properly and effectively utilized.

Mandate. The mandate of the audio-visual communication unit is to develop the infrastructure for the use of audio-visual media for agriculture in Pakistan, to train staff in media production, dissemination of media, and targeting technical information packages; and to construct and equip a multimedia production studio at NARC.

Current programme. The construction of an AV studio building which includes training facilities, started in August, 1988 and is expected to be completed within 18 months. The studios will serve the needs of all the member institutions of the federal and provincial agricultural research network. The studio facilities will include a video production unit with high-performance, professional view cameras, recorders, editing facilities, and a control room; a sound production unit with professional recorders mixers and audio filters; five portable electronic multi-media field production units; 20 portable multi-media display units to be used throughout Pakistan in support of the seminar, conference, and training facilities of the research network.

Proposed programme

- Designing and producing audio-visual materials in support of agriculture based on surveys and analysis of information transfer needs.
- Planning and producing videotapes, audio programmes, and slide/sound presentations dealing with agricultural research for scientists and educators.
- Organizing training programmes in information transfer and agricultural communications.
- Producing modules such as "Agricultural Research—Pakistan". This audio-visual presentation outlines the evaluation of agriculture research in Pakistan.
- Providing day-to-day services to PARC/NARC regarding the design, production, and utilization of audio-visual communication materials.

- Developing linkages with provincial media centres to provide technical guidance and materials.
- Production of programmes highlighting agricultural scientific research for telecast through Pakistan Television and Radio Pakistan.
- Undertake research in communication methodology, and provide support in communication activities to provincial bureaus. A central media library consisting of audio-visual materials produced in Pakistan and in other countries will be established at NARC for utilisation by both national and provincial communication bureaus.

Library Services and Documentation

Mandate. To keep the scientific community abreast and updated on the latest developments in their areas of activity.

Goals and objectives. The principal aims are:

- To maintain a central library at NARC including the latest books, journals, and microfilms, fiches, and video materials and prepare a union catalogue of books and a list of journals.
- To implement AGRIS, the international information system for agricultural science and technology of FAO, at the national level, including the establishment of a network of AGRIS liaison centres at the provincial level.
- To extend selective dissemination of information (SDI) and current content services at the national level.
- To implement CRISP, the current research information system for Pakistan, and participate in the CARIS, the current agricultural research information system of FAO.
- To established a PARC bibliographic database comprising NARC library holdings and develop a database containing agricultural literature on Pakistan.
- To set up a microfilming/fiche production facility for NARC and provincial AGRIS sub-centres, as well as for other concerned agricultural institutions.
- To arrange projection and photographic services for PARC and NARC management and scientists.

Current programme. The library provides library bulletin, current content service, literature scanning service, and routing-slip service. The documentation unit handles AGRIS input, SDI service, bibliographic service, document delivery service, and feed and uses services of NFIS, and PHIS systems. It also manages two databases, i.e., PARC bibliographic database (library catalogue) and Pakistan agriculture database.. The research information system unit handles CRISP and CARIS. The reprography unit provides microfilming, audio and projection services, technical photography, and slide-making services.

Proposed programme. The current services will be computerized with emphasis on the establishment of a decentralized national-level CD-ROM network to acquire and disseminate the various types of research information. Provincial agricultural libraries will be strengthened through the provision of library materials, equipment, and training of their staff.

Central Store

When the central store building was started in 1984, 73 programmes were functioning independently at NARC and maintaining their own record of store items. In 1985 the chairman of PARC directed that all supplies should be handled by the central stores.

Goals and objectives. The principle aims are:

- To store and provide equipment, chemicals, glassware, and other local supplies to the laboratories and research programmes at NARC.
- To keep records of stores and supplies.
- To dispose of unserviceable stores and farm produce of NARC.

Mandate. The NARC central store is to serve all research laboratories at campus as well as other research stations outside NARC in connection with supply of technical and local stores, to maintain the records, and to provide help in installation of advanced equipment.

Proposed programme

- Computerization of all stores.
- Expansion of store building.
- Training of staff.
- Bulk purchasing of glassware and chemicals for all projects.

Procurement Cell

The procurement cell at NARC purchases laboratory equipment, chemicals, glassware, agricultural machinery, office equipment, spare parts, stationery, furniture/fixtures, and allied equipment and services. The purchases are made according to the government procedures. Other responsibilities are preparation of tender documents, scrutinizing of bids, awarding contracts, arranging exemptions, import permits, insurance covers, records of supplies, and clearance of stores from the airport.

There is no regular staff in this section, it is headed by a procurement officer, who is on the payroll of the accounts branch of PARC. There is need to strengthen this section to handle the purchases of 75 programmes. No imprest money is at the disposal of the procurement section. The procurement officer has no financial powers to purchase even an item of one rupee. For smooth performance, the procurement section of NARC requires special consideration and reorganization. A vehicle is also needed.

Farm Operations and Services

The farm operations and services unit mandate is to allocate land and provide farm services to scientists and to develop a system for experimental land use and management. The unit supervises experimental land use and allocates land to researchers for experiments, demonstrations, etc. It prepares and maintains land, conducts farm machinery operations, and provides repair and maintenance services. It also manages the irrigation system and water schedules and maintains roads and farm shop facilities. By the year 2000, farm operations and services intends to be computerized with complete field histories and production performance records.

Transport Services

The transport services unit provides transport for NARC scientists to and from work and the children of NARC staff to and from schools. Transport is also provided for research and research support activities, training courses, and visitors. Vehicles in the NARC motor pool include 4 Bedford buses, 3 Toyota Coasters, 2 Mazda mini buses, 4 Toyota Hiace, and 28 other vehicles. Some of the vehicles in the NARC transport pool have been running for 10 years and they break down frequently. Keeping them running requires heavy expenditure on repairs. One or two new vehicles should have been added every year to replace old vehicles, which should have been withdrawn after having completed their economic life.

Automobile Workshop

The automobile workshop provides repair and maintenance services for NARC/PARC vehicles.

Works, Repair, and Maintenance

The works, repair, and maintenance unit is responsible for ensuring that NARC buildings are kept in good condition to ensure neat appearance and a fair service life. The unit also supervises development projects. Site measurements, verification of bills and claims of the contractor, and preparation of design, estimates, and specifications for small works are all responsibilities of the unit.

Laboratory Equipment and Maintenance

The laboratory equipment maintenance and repair unit at NARC provides technical support services to the agricultural researchers by taking the responsibility for installation, commissioning, repair, and maintenance of all laboratory equipment at NARC complex, PARC outstation laboratories etc. The repair and maintenance facility and technical guidance will be extended to other federal and provincial research organizations and agricultural universities by establishing four substations at provincial locations such as Quetta, Tandojam, Faisalabad, and Peshawar to serve local needs.

Space Allocation

A committee was constituted by the Board of Management, NARC, to set policy for space allocation at the NARC campus and laboratories block and to monitor space allocation continually. The committee comprises the DDG as convenor and the XEN, NARC, the deputy director of laboratories, and the directors of CDRI, ASI, and PSI as members.

The space allocation committee is responsible to the director general and is commissioned to accommodate all personnel and allocate requisite space according to the following policy guidelines.

- Programmes of the allied disciplines will be accommodated in the same wing or block.
- At least one office room in each institute/laboratory wing will be reserved for expatriates.
- All the new entrants of PSO level serving as programme leader will be provided an independent office, but those without responsibilities of project incharge will have to share an office with other PSOs of the section.
- The SSOs returning after earning graduate degrees will be accommodated jointly in the offices already allocated to SSO of the same section.
- The scientists (BPS 18 and above) from the provinces, coming to NARC on special assignments will be provided laboratory facilities or office space.
- The Ph.D students of PARC/NARC and other post-graduate students from agricultural universities, coming to NARC for training or thesis work etc., will be placed in appropriate laboratories.
- All SOs of the central laboratories system will be located in appropriate working laboratories.
- The space required for the proper operation of the major laboratory equipment for different programmes will also be allotted by this committee.

Requests for new programmes or additional space, office should be sent to DDG, NARC

through programme leaders. The DDG will send the request to the committee for action in accordance with the established policy.

Germplasm

The plant introduction centre is responsible for identification, introduction, and import of exotic plant species with high economic value, their acclimatization, and exploitation them for commercial cultivation in the country. The centre at NARC also makes efforts to meet the germplasm requirements of the scientists working in provinces, universities, and federal organizations. The plant introduction centre functions as focal point for incoming and outgoing germplasm and ensures the phytosanitary condition of the seed material.

In the last 5 years, the plant introduction centre imported more than 3000 accessions of over 68 plant species from 45 countries. The material was either evaluated at NARC or distributed to different research organizations. The emphasis has been on tropical legumes, horticultural plants, medicinal plants, and edible and industrial oil-bearing plants.

The plant genetic resources programme at NARC has organized 18 plant-collecting expeditions in the country and has collected more than 14,000 accessions of all the major crops. The materials have been documented and preserved in the gene bank for mid-term storage. The material is being evaluated and documented and is available to the scientists of the whole country for utilization in breeding programmes.

National Herbarium

The National Herbarium was founded in 1912 and transferred from Gordon College, Rawalpindi, to the Agricultural Research Council in 1975. The plant collection, is at present kept in a rented building. The construction of a building facility at NARC to house the collection is planned.

The collection comprises 75,000 dried herbarium specimens and valuable books. It includes materials collected as much as 125 years ago and provides excellent reference material for researchers in all fields of plant sciences especially ecology, agriculture, silviculture, environmental and evolutionary studies, medicine, etc. As a result of the research carried out by the scientists of the herbarium, 176 research publications have been widely distributed among the scientists and libraries both at home and abroad.

The large number of introductions of exotic plant species in various ecological zones of the country necessitates that the original plant wealth of the country be preserved for future studies to understand evolutionary changes.

The principal aims are:

- To strengthen and establish the national herbarium at NARC.
- To serve as a repository for valuable plant type specimens and to build up a reference collection through plant collection and exchange.
- To serve as a plant identification unit for research-oriented disciplines in agriculture, forestry, etc.
- To provide facilities to scientists from within the country and abroad and to postgraduate students for research work.
- To sponsor research in plant taxonomy and related fields and to publish research work.

Training Institute

Goals and objectives. The principal aims are:

- To provide opportunities to continually improve the scientific and technical capabilities of researchers.

- To accelerate the acquisition of knowledge and skills that will advance production technology, management, and communication.
- To strengthen linkages between researchers, extensionists, and farmers.

Mandate. Organize lectures, seminars, symposia and workshops for scientists in the national agricultural research system. Assist researchers, extensionists and farmers to keep abreast of latest technological developments by supplementing universities and technical centres in meeting the demand for competent personnel.

Current programme. More than 4000 participants have participated in 100 various courses since the training institute was established in 1983. The trainees participate in a learning-style inventory test. All courses and trainers are evaluated at the end of each course.

Proposed programme. Future training will emphasize:

- An annual pre-service (or refresher) program lasting 9 to 12 months for new professional staff and others who would benefit from such experience.
- A minimum of 10 short courses annually in advanced scientific subjects for professional staff. Once conducted at the training institute, on demand, some of the courses might be repeated in one or more provinces.
- Special short courses for specific groups of technical and administrative *support* personnel. Once established, the courses might be repeated periodically, as necessary to reach new supportstaff.
- Annual workshop on how to organize, conduct, and evaluate short courses, workshops, and similar short-term training.

To the extent that staff, facilities, and other resources permit, the institute will offer a number of short courses and workshops for extension workers and key farmers. This will help the training institute to maintain effective links with extension and farmers, while simultaneously developing and demonstrating training activities more appropriate for use in provincial training institutes and by extension in working with farmers.

All of these activities, with the new orientation to preparing people for the research system, will contribute significantly to developing a post-graduate capability at the training institute.

RESOURCE REQUIREMENTS:
LIBRARY SERVICE AND DOCUMENTATION

LIBRARY SERVICES AND DOCUMENTATION: Resource Requirements

Project Title	Priority	1988 / 89		1989 / 90		1990 / 91		1991 / 92		1992/93-1995/96 Annual average		1996/97-1999/00 Annual average	
		Staff*	Op.F**	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F	Staff	Op.F
1. Current awareness services.	1	1.0	91408	2.0	92600	2.0	212000	3.0	340000	3.0	247800	3.0	323000
2. AGRIS	1	1.0	130000	1.0	138000	1.0	105900	1.0	130000	1.0	105000	1.0	134000
3. PARC Bibliographic Database/Pakistan Agriculture Database	1	2.0	172000	2.0	180000	2.0	196000	2.0	220210	2.0	158000	2.0	246000
4. CRISP	1	0.0	112000	1.0	118300	1.0	128000	2.0	240500	2.0	188000	2.0	260000
5. Local Area Network/CD-ROM System/Electronic Mail/Expert Retrieval System.	1	0.0	173000	1.0	185000	1.0	116285	1.0	120000	2.0	206000	2.0	235000
6. Microfilming.	1	1.0	128000	1.0	130000	2.0	209000	2.0	240000	2.0	168000	3.0	342000
7. Union List of Journals.	1	2.0	72000	2.0	83000	3.0	325000	3.0	340000	3.0	258156	4.0	426000
8. Library Computer Network/Inter-Library loan/ Union List of Books.	2	-	-	-	-	-	-	-	-	1.0	127000	2.0	200103
Total		7.0	878408	10.0	926900	12.0	1292185	14.0	1630710	16.0	1457956	19.0	2166103

BUDGET							
	Staff Costs: Existing (1988/89 + 3%/year)	1136592	1170690	1205810	1241985	2453405	3592030
	Additional	0	219660	166842	191868	177647	228584
	Operational Funds	878408	926900	1292185	1630710	1457956	2166103
	Total (1988/89 + 15%/yr through 1991/92, then + 10%/yr)	2015000	2317250	2664838	3064563	4089008	5986717

* Number of scientists (BP 17-20) 1 PSO, 2 SSO, 4 SO. Includes those on study leave or secondment.

** Operational Funds = Total budget (in rupees) less salaries and allowances, rent of residential buildings, and pension contribution

6
A Post-Graduate Capability at NARC

The NARC training institute was started in 1983 to train working scientists with different educational backgrounds and varying experience. During the last 5 years, it has trained over 4000 scientists across the country through 130 short courses on topics of national interest. Owing to the success of such courses, the training institute has since 1987 extended its facilities to post-graduate students of all agriculture universities of Pakistan. The National Commission on Agriculture has also proposed upgrading the present training facilities to academy level. Once the academy is established, more qualified personnel will be recruited to meet the future training needs of the country.

Post-graduate research will prepare the scientists to assume responsible positions in research and management in their organizations. To implement the post-graduate training programme, the training institute will collaborate with the universities all over the country. The students will complete their course requirements at the universities and later come to NARC to conduct thesis or dissertation research under the guidance of experienced scientists who will also act as co-supervisors. The creation of the post of deputy director of advanced studies would be enough in addition to the existing establishment to handle the programme.

For post-graduate research, sufficient technically competent staff and laboratory facilities are available. During their stay, students will be accommodated at the NARC hostel, which is being expanded. A small monthly stipend will be provided to each student depending on the level of degree being pursued. For such training, personnel with the required practical experience and educational qualifications will be identified to provide technical guidance to the trainees.

The directorate of the training institute in association with the research programme leaders in various disciplines of NARC constitutes the training components.

Learning by doing could be an effective tool in training research scientists by sharpening their present knowledge, skills and, attitude. Being at the national level, NARC has acquired some advanced equipment which is not available in the provinces and as a result, new research techniques are emerging which should be disseminated through training programmes. One example, is the summer internship programme which has already been started. Ten top students from each of three agricultural universities come to work in close association with NARC scientists for 2 months during summer vacations.

The training institute has expanded its linkages with national and international centres. Course coordinators have been appointed in each province to help develop and conduct courses. Collaboration with international agencies like ICARDA, CIDA, CIMMYT, FAO, and USAID has also been developed in such a way that NARC training institute is now being recognized as a regional training centre.

7
A Summary of the NARC Total Budget and Manpower Status 1988-2000

The manpower, operating and total budgets for each NARC research institute and grand totals for the period 1988-2000 are presented below. The reader is reminded that initially (1988) the operating funds for NARC were about 20 percent of the total budget. Staff and budget increasesd through year 2000 are based on the recommendations of the National Commission on Agriculture. The Commission also recommended to raise the operational research budget significantly. Consistent with the Commission's recommendations, the Master Research Plan operational research budget by year 2000 is increased almost six-fold while only a three-fold total budget increase is planned.

It is to be noted that the GOP total NARC 1989-90 budget research allocation has not increased. Indeed, the research operating budget has decreased. This trend will need to be reversed if the Master plan is to assist NARC rapidly emerge as a Centre of Research Excellence and to serve the Pakistani farmer.

SUMMARY TABLE

	MANPOWER		OPERATING BUDGET		TOTAL BUDGET	
	1988	2000	1988	2000	1988	2000
PLANT SCIENCES INSTITUTE						
WHEAT, BARLEY, TRITICALE	11	17	316000	2177360	2025472	6017830
RICE	14	20	390000	2270545	2112156	6275375
MAIZE	6	10	186000	941458	875784	2602020
SORGHUM AND MILLET	3	8	169000	551616	513136	1524566
FODDER CROPS	4	8	68000	609231	566732	1683804
PULSES	14	16	135000	1765322	1642176	4879029
OILSEEDS	8	15	554000	1934970	1799624	5346818
SUGAR CROPS	1	2	63000	288725	268584	797983
VEGETABLE CROPS	7	15	27000	917993	853956	2537168
FRUIT CROPS	9	11	110000	1002419	932492	2770504
SEED SCIENCE AND TECHNOLOG	9	9	467024	1255115	1167560	3468909
PLANT GENETIC RESOURCES	3	8	30000	523051	486564	1445618
PLANT INTRODUCTION CENTRE	2	3	63000	362215	336948	1001098
TISSUE CULTURE	7	9	100000	1058259	984436	2924834
CYTOGENETICS	5	8	24000	476302	443076	1316412
FOOD TECHNOLOGY	8	10	112000	1196326	1112872	3306427
TOTAL	111	169	2814024	17330907	16121568	47898395

PLANT PROTECTION INSTITUTE						
CROP DISEASES RESEARCH INST	25	33	630000	3633060	3057024	9082649
PLANT VIROLOGY	5	6	80000	611140	568508	1689080
ENTOMOLOGY	20	23	67000	2094414	1949312	5788582
WEED SCIENCES	8	10	94000	1044120	971284	2885758
VERTEBRATE PEST MANAGEMENT	4	6	150000	792444	404700	1292394
TOTAL	62	78	1021000	8175178	6950828	20738463
ANIMAL SCIENCES INSTITUTE						
ANIMAL BREEDING & GENETICS	3	3	103111	402458	374383	1112320
REPRODUCTIVE PHYSIOLOGY	5	6	162639	635825	591471	1757305
EMBRYO TRANSFER	3	4	157324	614450	571588	1698231
MEAT PRODUCTION	2	3	82914	322658	300150	891768
DAIRY TECHNOLOGY	2	4	105237	411038	382365	1136035
POULTRY	2	3	286000	597642	555952	1651775
ANIMAL NUTRITION	6	14	320000	1610583	1499232	4451360
ANIMAL HEALTH	6	13	451775	1506472	1401383	4163615
SHEEP AND WOOL	3	3	137000	538708	501128	1488889
GOAT PRODUCTION	1	3	460000	1004221	934168	2775484
FISHERIES	7	11	306000	1060009	986064	2929671
TOTAL	40	67	2572000	8704064	8097884	24056453

SUMMARY TABLE

	MANPOWER		OPERATING BUDGET		TOTAL BUDGET	
	1988	2000	1988	2000	1988	2000
SOIL AND WATER INSTITUTE						
SOIL FERT.& PLANT NUTRITION	11	14	80000	1132746	1053728	3130705
SOIL CHEMISTRY & MINERALOGY	5	9	70000	574358	534292	1587422
SOIL BIOLOGY	3	6	45000	618301	539760	1708873
SOIL PHYSICS	5	6	72000	535396	498048	1479738
STRESS PHYSIOLOGY	3	4	40000	327931	305056	906344
SOIL AND WATER CONSERVATION	9	13	304500	1751325	1629156	4840345
IRRIG. SYSTEMS & MANAGEMENT	6	8	138000	878481	817200	2427963
AGRO-METEOROLOGY	3	7	16000	315174	293188	871384
ECOLOGY	4	4	222512	597995	556283	1652750
REMOTE SENSING	5	5	51000	579966	539508	1602919
AGRO-FORESTRY	3	4	94000	392664	365272	1085251
FORAGE AND PASTURE	8	9	55000	1023364	951976	2828393
APICULTURE	4	9	142000	994843	925444	2749564
SERICULTURE	1	2	28240	160878	149656	444639
TOTAL	70	100	1358252	9883422	9158564	27316290

FARM MACHINERY INSTITUTE	22	25	1272000	4268593	3970824	11797618
SOCIAL SCIENCES INSTITUTE						
AGRICULTURAL ECONOMICS	2	21	18500	2672400	18500	668;000
COMPUTER AND STAT SERVICE	3	5	121300	602609	560572	1665502
FARMING SYSTEMS RESEARCH	10	10	498137	2014662	1155828	3434052
LIBRARY SERVICES & DOC.	7	19	878408	2166103	2015000	5986717
TOTAL	22	55	1516345	7455774	3749900	17767271
GRAND TOTAL FOR NARC	268	420	10553621	55817938	48049568	149574490

	OPERATING BUDGET		TOTAL BUDGET	
	1988	2000	1988	2000
P.S.I.	2814024	17330907	16121568	47898395
P.P.I.	1021000	8175178	6950828	20738463
A.S.I.	2572000	8704064	8097884	24056453
N.R.I.	1358252	9883422	9158564	27316290
F.M.I.	1272000	4268593	3970824	11797618
S.S.I.	1516345	7455774	3749900	17767271
TOTAL:	10553621	55817938	48049568	149574490

Glossary

A program is a broad but carefully defined plan of a researcher that is usually multidisciplinary, involving the coordination and skills of scientists from more than one institute.

A project is a component of a program, more specific in scope and objectives yet more detailed in terms of what, how, where, when and by whom the work will be done.

A sub-project or experiment is a part of a project which is carried out in the laboratory or field with even more specific objectives and work plan.

An objective is a brief statement of a purpose toward which the research is directed or, what an organization aims to produce.

Baseline data: Data collected before a project begins, e.g., on crop yields, livestock production, labor input, or market prices, against which a project's results can be evaluated.

Collaborating farmers: Farmers chosen or who have volunteered to cooperate with an farming systems research project by (1) allowing researchers to conduct experiments on their farms, or (2) agreeing to test and evaluate new technology themselves.

Commodity-oriented research: Focuses on one or more crops or animals by studying them in detail. Commodities selected for emphasis should be the result of prior investigation demonstrating their importance to the farming system.

Cropping systems: Systems within the farming system. They comprise one or more crops and all components involved in production, including the interactions among crops, other household enterprises, and the physical, biological, and socioeconomic environments.

Disciplinary research: Approaches the object of study—in this case the farming system or a portion of it—from the perspective of a particular discipline, e.g., economics.

Ecosystems: Broad sets of growing conditions, characterized in terms of climate, soil, vegetation regimes, chosen as the focus for program thrusts: irrigated, rainfed lowland, upland, wetland, etc.

Experiment: A test made to examine the validity of a hypothesis or to determine the efficacy of something previously untried.

Experimental variables: Those variables in an experiment that the researcher is testing.

Farmer-managed tests: On-farm experiments managed by farmers to learn how farmers respond to suggested improvements

Goal: The ultimate purpose that guides the activities. It can be attainable only by concerted activities or elements.

Informal surveys: Surveys undertaken without sampling procedures, pretested questionnaires, and other means that permit statistical analysis of the data.

Interdisciplinary: Involves frequent interactions by those from different disciplines working on common tasks and coming up with better results than had they worked independently.

Levels of research: The type of research activity being undertaken. The shift from applied to strategic research is often termed "moving upstream". Thus, the term upstream does not describe a category of research, but the direction of movement along the continuum.

- Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, with no particular application or use in view.
- Strategic research selects, evaluates, and develops, from available knowledge and emerging concepts or tools to solve existing and anticipated applied research problems. It links basic and applied research.
- Applied research, also undertaken to acquire new knowledge, is directed primarily toward a specific aim to resolve a particular problem.
- Adaptive research is systematic work that draws on knowledge gained from applied research to produce new materials, products, and devices, and to adapt existing technology to specific circumstances.

Mandate: What an organization is empowered by legal or constitutional authority to do.

National agricultural research system: The aggregate of science and technology institutions (including universities) and their activities related to agricultural research in a given country (also used are "coordinated programs", "national rice research programs").

Nonexperimental variables: Those variables in an experiment that the researcher is not testing. They are divided into those that researchers cannot control, such as weather, and those that they can control, such as farming operations.

On-farm research: In farming systems research, primarily conducting researcher-managed and superimposed trials and farmer-managed tests on farmers' fields; also conducting related studies of farm management and environmental conditions that influence the farmer.

Partial budget analysis: A "form of marginal analysis designed to show, not profit or loss for the farm as a whole, but the net farm income resulting from the proposed changes."

Pilot to production program: Designed to test how agricultural policies and support systems function when new technologies are introduced into an area on a large scale—e.g., 100 to 500 hectares.

Plan: A scheme and arrangements drawn up beforehand to accomplish a purpose.

Recommendation domain: "A group of roughly homogeneous farmers with similar circumstances for whom we can make more or less the same recommendation.

Reconnaissance survey: A field survey method of data collection that usually comes after secondary data collection.

Research: A scientific investigation or enquiry.

Strategy: The art of conducting a systematic campaign or study.

Subsistence farmers: Farmers producing primarily for their own needs, with the resulting low capacity to purchase inputs for production.

Superimposed trials: Relatively simple researcher-managed experiments applied across a range of farmer-managed conditions.

Support services: Systems that will determine the appropriateness of a new technology, e.g., roads, transportation, markets, available credit, irrigation, and sources of supply for seed, herbicides, and fertilizer.

System: Any "set of elements of components that are interrelated and interact among themselves. Specification of a system implies a boundary delimiting the system from its environment.

Target area: A geographical area selected for an farming systems research project based on the needs of the people living there or to take advantage of the area's agricultural potential. Criteria for selection are normally set by key national and regional decision makers.

Whole farm approach: An essential characteristic of farming systems research teams, which look at the whole farm setting to identify problems and opportunities, note interrelationships, design and conduct experiments, and evaluate results.

Annexures

Annex I. Advanced Instruments, Central Laboratory Complex, NARC

1. Amino Acid Analyzer—6300 Beckman System, 1983.
2. Autoanalyzer II, Technicon II
3. Analyzer Near Infra NECOTEC 51-A, 1986
4. Atomic Absorption Spectrophotometer, Perkin Elmer
5. Automatic Mill Type MLU-202, 1988
6. Centrifuge Refrigerated Beckman J2-21, 1983
7. Differential Thermal NE TZSCH 4045, 1987
8. Electro Ultrafiltration Machine, E.U.F. 724, 1985
9. Exentenosorgraph Brobender DM 90-40, 1980
10. Falling Number Type 1600, 1987
11. Fibertec System—1023 Filtration Module, Tractor 100 2100, 1985
12. Flame Photometer Corning 410, 1983
13. Flame Photometer Perkin Elmer Co. 510002, 1983
14. Farinograph—820803, 1980
15. Gas-chromatograph GL-9A, Scihmadzu
16. Gas-chromatograph ANTEK-300, 1983
17. HPLC, High Performance Liquid Chromatograph, Hitachi-100-40, 1983
18. Junior Brabender Milling Machine, 279002, 1980
19. Kgel Tec. Auto Analyzer 1030, 1000-1580, 1983
20. Klina Flame Photometer Beckman 6521, 1983
21. Micro Processor—LS 7500/DP Controlled Liquid. Scientiflation counter
22. NMR Analyzer Newport 4000-NA-4400, 1987
23. Photomicroscope NIKON Optiphot HFX-11, 1987
24. Refrigerated centrifuge L5-50, 1983
25. Spectrophotometer ingraved 4260, 1983
26. Scanning Electron Microscope JSM-35 CF, 1988
27. Senior Brabender Milling Machine 880700,1980
28. Soxtech System HT 1000-1580, 1987
29. Spectronic 501 B&L 0603, 1983
30. Spectrospan-V Beckman 486789, 1987
31. Spectrophotometer UV-VIS-NIR Beckman UV 5270, 1983
32. Spectrophotometer UV-34 VIS, 1983
33. Titertek Multiscan, 340 NC, 1987
34. Transmission Electron Microscope 100 CX II JEOL, 1988
35. Ultracentrifuge Beckman L-8180, 1983
36. X-Ray Diffractometer XRD 8536, Diffractometer, 1985

Annex II. Programmes and Projects of NARC

Plant Sciences Institute

1. Coordinated Research Programme on Wheat, Barley and Triticale
2. Coordinated Research Programme on Rice
3. Coordinated Research Programme on Maize
4. Coordinated Research Programme on Sorghum and Millet
5. Coordinated Research Programme on Food Legumes
6. National Coordinated Fodder Research Programme
7. Coordinated Research Programme on Sugar Crops
8. Coordinated Research Programme on Oil Seed Crops
9. Coordinated Research Programmes on Fruits and Vegetable Crops, Olive and Mushrooms Crops
10. Plant Introduction Center
11. Plant Introduction and Genetic Resources
12. Tissue Culture Programme
13. Nutritional Quality and Consumer Acceptance of Food Crops Grown in Pakistan
14. Investigation of Virus Diseases of Crop Plants in Pakistan
15. Entomological Research Laboratories
16. National Research Programme of Weeds
17. Cytogenetics Research Programme
18. National Herbarium Project

Natural Resources Institute

19. Coordinated Research Programme on Micronutrient State of Pakistan Soils
20. Coordinated Research Programme on feasibility Study and Development of Low Cost High Efficiency Irrigation System (trickle and sprinkler).
21. Research Project on Strengthening and Establishing of Agro-met Stations and Collection of Agrometeorological Data for Fine Tuning of Agro-ecological Zones in Pakistan
22. Improvement of Water Measurement and Control System Development and Conservation in Pakistan
23. Improvement of Water Management and Conservation Practices in Barani Areas of Pakistan for Increased Crop Production
24. Coordinated Research Project on Forage and Pasture

25. Coordinated Programme on Agro-ecology Zoning Problems
26. Research Project on Remote Sensing for Crops and Natural Resources
27. Range Research Project of Pothwar
28. Coordinated Research Programme on Agro-forestry
29. Operational Research Project on Watershed management.
30. Physiological and Nutritional Studies of Selected Crops Grown on Pakistan Problem Soils.
31. Research Project on Biological Nitrogen Fixation
32. Honey Bee Management Research livestock Institute
33. Poultry Performance Testing
34. Coordinated Research Project for Livestock Feed Resources and Nutrition at NARC
35. Coordinated Research Project on Improvement of Sheep and Wool at NARC
36. Coordinated Research Project on Dairy Cattle Cross Breeding
37. Coordinated Research Project on Meat and Meat Technology
38. Study on Epidemiology of Major Livestock Diseases in Pakistan
39. Coordinated Research Project on Improvement of Goats
40. Fisheries and Aquaculture in Rawal lake
41. Coordinated Research Projects on Controlled Breeding and Mass Rearing of Larvae and Fry *Catla catla*.

Social Sciences

42. Agricultural Economics Research unit
43. Computer and Statistics Section, NARC
44. Transfer Technology Unit

Special Projects

45. Crop maximization Programme
46. BARD (Barani Agricultural Research and Development) project
47. Farm Machinery Institute
48. Training Institute
49. Planning/Research Monitoring and Coordination
50. Scientific and Technical Information Unit
51. Lab. Equipment Maintenance and Repair Unit

Annex III. Technical working groups and the corresponding disciplines

TWG	*Subjects/Disciplines*
1. Agricultural Mechanization Institute	i. Farm Machinery
2. Cereal and Fodder Crops	i. Wheat ii. Maize iii. Sorghum and Millet iv. Rice v. Fodder Crops vi. Food Nutrition
3. Crop and Environmental Protection	i. Plant Protection ii. Plant Virology iii. Weed Sciences iv. Entomology v. CDRI
4. Environment and Forestry	i. Watershed ii. Rangelands iii. Remote Sensing iv. Forestry
5. Farming Systems	i. Weed Sciences ii. Land and Water Resources iii. Cereal and Fodder Crops iv. Agricultural Economics
6. Honeybee and Sericulture	i. Honeybee Management ii. Sericulture
7. Horticulture, Sugar and Special Crops	i. Plant Introduction ii. Plant and Genetic Resources iii. Sugar Crops iv. Fruits v. Vegetables vi. Tissue Culture vii. Cytogenetics
8. Land and Water Resources	i. Land Resources ii. Water Resources
9. Livestock, Poultry and Fisheries	i. Livestock ii. Poultry iii. Fisheries
10. Pulses and Oilseed Crops	i. Pulses ii. Oilseed
11. Socio-Economics and Technology Transfer	i. Agri-Eco-Res Unit (AERU) ii. Computer and Statistics iii. Technology Transfer

Annex IV. NARC Master Plan Implementation Activities and Schedule

Activities	Time Frame				
		1990			
	1989	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Board of Governors and Policy Advisory Committee:					
- Published M.P. Dispersement	x				
- Follow up Action	xx				
- Provincial Master Plans	x	x	x	x	x
M.P. Inauguration:					
- Board of Management	x	x	x	x	x
- Organization & Administration	x				
- Planning, Review and Monitoring Cell (PRMC). Appointments and Terms of Reference	xx	xxx	xxx	xxx	xxx
Research Committee:					
- Programs Implementation Strategy	x	x		x	
- Selection of Priority Research Thrusts	xx	x		x	
- Programs/Projects and Resource Allocations	x	xxx	xxx	xxx	xxx
- TW Groups & 1990/91 Work Plans		x		x	x
- Institutionalization of FSR Cell	xx	x	x	x	x
Research Management Upgrade:					
- Strategy and scope to implement	xx				
- Selection of Consultants	x		x	x	x
- Training in Research Management	x	xx	xx	xx	xx
- Human/Personnel Management Model	x	x	x	x	x
- Financial Management Model	x	xxx	xxx	xxx	xxx
- Monitoring and Review	x	x	x	x	x
Support Services Model Performance:					
- Strategy and Scope of Implementation	x				
- Procurement/Central Stores	x	x	x	x	x
- Communications/Library/A.V.	x	xxx	xxx	xxx	xxx
- Repairs Maintenance	x	xxx	xxx	xxx	xxx
- Training Institute	x	x	x	x	x

NARC MASTER RESEARCH PLAN

QUESTIONNAIRE

PRELIMINARY ANALYSIS

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SUMMARY

Analysis of scientists responses to the questionnaire has resulted in useful information for writing of the NARC Master Research Plan. Informal meetings among project teams have been held to consider issues raised in the questionnaire. Areas in which research gaps exists and priority research topics have been recommended by the scientists. Strategies to strengthen linkages between NARC scientists and with scientists working in other national and international organizations were articulated. Scientists also criticised existing procurement procedures and suggested improvements in establishing the relevance of NARC research to the needs of farmers. Facilities for most of the part appear to be a minor constraint to most NARC scientists. However, there were several aspects of research management which suggest writers of the Master Plan may need to address. Scientists have indicated that operational funds for research are neither adequate nor are provided on schedule.

INTRODUCTION

No other activity of an Agricultural Research Centre exceeds in importance than a well conceived and developed research program. The purpose of the NARC Master Research Plan is to provide NARC with an orderly plan to pragmatically solve major constraints in Agricultural Production with its available resources. The goals and guidelines depicted in the plan should lead to the development of a National Centre of Research Excellence. Research program thrusts, human resource development, support services, required physical facilities and budget/financial needs will be articulated in the Master Research Plan.

The NARC Research Plan will represent what NARC stands for, what it hopes to achieve and the style of research it intends to use. The aim of the Master Research Plan is to convert NARC resources into useful products which include such things as research results, technological information, materials and scientific expertise. The plan will be designed to meet urgent needs of the country and to have research organized to produce results quickly and efficiently making the most possible use of available manpower, physical facilities and financial resources. The Master Research Plan will also suggest reallocation of resources to solve the most important and urgent problems first.

The prime users of the Master Research Plan would be the Director General NARC, his Directors, Project Leaders and NARC scientists. The Master Research Plan would also be an important document for PARC especially the Executive Committee.

Ministry of Finance and Planning would find the Master Research Plan useful while the Master Research Plan would provide useful information to both provincial institutions and potential donor agencies.

The Master Research Plan was inaugurated by the Chairman PARC on 16th July 1987 who also provided an over view of the importance and scope of this plan.

As a part of the effort in preparing a NARC Master Research Plan, a questionnaire was circulated to staff. Each NARC scientist (SO & above) was requested to respond and give details of his/her research activities. Comments relative to NARC services and facilities were also solicited. The questionnaire was distributed to over 200 staff on July 23, 1987. Scientists from 37 different Projects/Programs responded to the questionnaire. More than 90 percent of the scientists answered the questionnaire. Analysis of responses of the objective type questions was carried out on the basis of different ranks of the scientific staff as well as for each research group or discipline separately. For the analysis of the responses in which detailed informations were provided, the informations given by all the scientists of a particular research group were summarized into a few brief statements and percentage of the scientists with similar responses given at the end of each statement.

HAVE YOU STUDIED ABROAD. IF "YES", STATE PERIOD/LOCATION.

PROGRAM	SER.NO. ASSIGNED TO. C.	PERIOD	LOCATION
RICE	1	1 Year 2 Month	Philippines (IRRI)
	3	1 Year	Italy (Vercelli)
	4	1 Month	Philippines (IRRI)
MAIZE	7	2½ Year	Queensland
SORGHUM & MILLET	8	6 Month	Thailand (Bangkok)
SUGAR	10	3 Month	Mauritius (RSTCA)
OILSEED	11	2 Month	Yugoslavia (Novisad)
	12	3 Year	USA (Ohio State University)
	13	4 Year	USA (U.C. Davis, Cal.)
	16	3 Year	USA (Oklahama State Univ.)
PULSES	23	6 Month	Canada
FRUIT			
VEGETABLE	28	10 Month	Japan (JICA)
	30	3 Month	The Netherlands (IAC)
PLANT VIROLOGY	36	(a) 3 Year	Lebanon (Am.Univ. of Beirut)
		(b) 5 Year	Australia (Adelaide Univ.)
	37	?	Bulgaria
TISSUE CULTURE	40	(a) 5 Year	France (Univ. de Paris)
		(b) 2 Year	Canada (Univ. of Alberta)
PGR & PIC	44	3 Year	Romania (Bolyai University)
	45	1 Year	U.K. (Univ. of Birmingham)
	46	1 Year	U.K. (Univ. of Birmingham)
ENTOMOLOGY	47	5 Year	Canada (Montreal)
	49	4 Year	U.K.
	51	4 Year	U.K. (Glasgow)
	51-a	(a) 1 Year	Italy
		(b) 1 Month	Thailand
	51-f	15 Days	USA (Colorado State Univ.)
WEED	56-a	3 Year	
FODDER			
CYTOGENETICS	60	3+3 Year	U.K. (London)
	61	2½ Year	USA (Univ.of Hawaii)
GRAIN STORAGE			

PROGRAM	SER. NO. ASSIGNED TO Q.	PERIOD	LOCATION
BARD	67-a	-	CSU, NCSU
	67	4 Year	U.K. (Univ. of Liverpool)
	73	3 Year	Lebanon (Am. Univ. of Beirut)
CDRI	80	3 Year	USA
	81	3 Year	Lebanon (Am. Univ. of Beirut)
	82	3 Year	USA (Kansas State UNiversity)
	83	3 Year	USA
	85	2 Month	USA
	86	13 Year	India
	87	4 Year	Canada (Mc Gill University)
N & FQ	87-a	3 Year	U.K.
	87-b	-	G.D.R. (Technical Univ. Merrelburg)
	87-h	3 Month	USA (CIMMYT)
WHEAT	89	Short Term	USA (CIMMYT)
LRS	94	6 Year	USSR (Moscow Agri. Academy)
	95	15 Days	U.K. (Brighton/Yorks.)
	100	(a) 3 Year	U.K. (The Queen's Belfast)
		(b) -	Tokyo
	103	2 Year	The Netherlands (Wageningen)
	108	6 Year	USA
	109	4 Year	Australia (Sydney)
	110	2 Year	Australia (Univ. of Queensland)
RANGE & WATERSHED	113	-	USA (Utah State University)
	114	4 Year	USA
	115	1 Year	U.K.
WATER RESOURCES	124	1 Year	Thailand (Bangkok)
	125	1 Year	Thailand (Bangkok)
	125-d	2 Year	-
SERICULTURE			
HONEYBEE RESEARCH	127	1 Month	USA
	130	3 Weeks	USA
ANIMAL SCIENCES INS	131	(a) 4 Year	Australia (Kensington)
		(b) 5 Year	USA (Pullman)
	132	5 Year	Australia
	133	4 Year	USA (Washington State Univ.)
	135	5 Year	USA (Georgia)
	136	3 Month	-
	138	2 Year	-
	148	1 Year	Philippines
	151	3 Year	U.K. (Liverpool Univ.)
	154	1 Year	Philippines
	159	3 Year	Newzealand

PROGRAM	SER. NO. ASSIGNED	PERIOD	LOCATION
FARM MACHINERY INS	164	1½ Year	Thailand (Bangkok)
	165	1½ Year	Thailand (Bangkok)
	167	1½ Year	Thailand (Bangkok)
	169	(a) 3½ Year	USA (Cornvell Univ.)
		(b) 2 Year	USA (Ohio State Univ.)
	171	6 Month	Japan
COMPUTER & STATISTICS	174	1½ Year	USA
	175	1½ Year	USA (Iowa State Univ.)
SCIENTIFIC INFORMATION UNIT.	178	3 Month	Australia
	179	3 Month	Philippines (IRRI)
AERU	183	3 Year	Australia (UNE, Armidale)

TOTAL NO. OF SCIENTISTS = 208, % STUDIED ABROAD = 37

OFF-CAMPUS PROFESSIONAL AND EDUCATIONAL MEETINGS ATTENDED DURING THE LAST 5 YEARS.

PROGRAM	SER. NO. ASSIGNED TO Q.	IN COUNTRY	DEVELOPING COUNTRY	DEVELOPED COUNTRY
RICE	1	1	1	-
	3	2	-	-
	4	1	-	-
MAIZE	5	2	-	-
	6	4	-	-
	7			2
SORGHUM & MILLET	8	-	2	-
SUGAR	9	5	-	-
OILSEED	12	-	1	
	13	3	-	1
	15	-	1	-
	16	-	-	2
PULSES	17	-	1	-
	23	-	2	-
FRUIT				
VEGETABLE				
PLANT VIROLOGY	36	-	3	2
TISSUE CULTURE	40	8	2	3
	40-d	2	1	-
	41	2	-	-
	42	3	-	-
PGR, PIC	44	-	1	-
	45	-	3	-
	46	-	3	-
ENTOMOLOGY	47	-	-	2
	48	1	-	-
	49	1	-	2
	50	-	1	-
	51-a	2	-	-
	51-b	2	-	1
	51-d	2	-	-
	51-e	1	-	-
	51-f	1	-	1
WEED	53	1	-	-
	55	2	-	-
	56-a	-	3	-

PROGRAM	SER. NO. ASSIGNED TO Q.	IN COUNTRY	DEVELOPING COUNTRY	DEVELOPED COUNTRY
FODDER	--	-	--	-
CYTOGENETICS	60	-	--	1
	61	-	-	2
	62	2	-	-
GRAIN STORAGE	65	2	1	-
BARD	67-a	-	-	3
	67	-	1	-
	72	-	-	2
	73	-	-	1
	76	3	-	-
CDRI	78	-	-	3
	79	-	-	3
	80	-	-	1
	81	-	1	-
	82	-	-	1
	85	-	-	1
	87	-	-	1
N & FQ	88-a	-	3	2
	88-b	-	-	1
	88-f	1	1	-
	88-h	-	-	1
WHEAT	-	-	-	-
LRS	93	2	-	-
	94	1	-	-
	95	3	-	1
	98	3	-	-
	100	-	-	3
	103	4	1	-
	108	1	-	-
	109	1	2	-
	110	-	-	2
	111	5	1	3
	112	5	-	-
RANGE & WATERSHED	114	-	-	5
	115	-	-	1
	116	1	-	-
	118	1	-	-
	121	-	1	-
WATER RESOURCES	125-c	-	1	-
SERICULTURE	-	-	-	-
HONEYBEE RESEARCH	127	-	2	1
	129	3	-	-

PROGRAM	SER. NO. ASSIGNED TO Q.	IN COUNTRY	DEVELOPING COUNTRY	DEVELOPED COUNTRY
ANIMAL SCIENCES INSTITUTE	131	2	–	–
	132	–	–	2
	133	–	1	1
	135	–	–	1
	136	4	–	–
	138	–	–	2
	139	1	–	–
	148	5	–	–
	150	1	–	–
	151	–	1	–
	152	2	1	2
	153	–	1	–
	154	4	–	–
	156	–	–	1
	159	4	–	1
TRAINING INSTITUTE	162	2	–	–
FARM MACHINERY INSTITUTE	164	5	–	–
	165	1	1	–
	167	2	2	–
	169	2	–	3
	170	2	–	–
COMPUTER & STAT.	175	3	–	–
SCIENTIFIC INFORMATION UNIT	178	1	–	–
	180	2	–	1
	181	1	–	–
AERU	183	2	1	1
	184	2	2	–
	185	1	–	–
	186	1	–	–

Total No. of Scientists	=	208
% Attended Professional & Educational Meetings	=	50
% Attended meetings In Country.	=	28
% Attended meetings in the Developing Countries.	=	16
% Attended meetings in the Developed Countries.	=	19

LIST BELOW PRESENT RESEARCH ACTIVITIES (BE SPECIFIC). ATTACH SEPARATE SHEET IF NEEDED.

Note: The following are statements which represent abstracts of Questionnaire responses.

RICE - TOTAL NO. OF SECTOR SCIENTISTS = 4	*PERCENT
1. Screening and evaluation trials for insect resistance and early maturity.	75
2. Chalkiness in rice in relation to physical dimension	25
3. Water absorption and volume expansion as affected by surface area index.	25
4. Improving quality of Basmati-370	25
MAIZE - TOTAL NO. OF SECTOR SCIENTISTS = 3	
1. Studies on insect pest control.	67
2. On-farm Research - verification trials, superimposed weed control trials, fertilizer trials and grain/fodder trials.	33
3. On-station project:- intercropping of maize with mung, soybean planted under different geometrical patterns.	33
4. Development of cold tolerant and early white and early yellow varieties for rainfed area.	33
SORGHUM & MILLET - TOTAL NO. OF SECTOR SCIENTISTS = 2	
1. Local germplasm evaluation.	100
2. Variety Trials.	100
3. Pure line selection and hybridization studies.	100
4. International pearl millet adaptation trials	100
5. Screening of sorghum varieties for N-fertilizer.	100
SUGAR - TOTAL NO. OF SECTOR SCIENTISTS = 1	
1. Maintaining local/exotic sugarcane germplasm at NARC.	100
2. Screening/evaluation of germplasm against diseases, frost and quality etc.	100
3. Coordination and field trials.	100
OILSEED - TOTAL NO. OF SECTOR SCIENTISTS = 6	
1. Monitoring, identification of new diseases, their isolation and pathogenicity tests.	50

2. Screening/breeding of soybean and sunflower against major insect diseases under artifical innoculation conditions/natural conditions in the field. 50

3. Studies on fertilizer and herbicide applications and nodulation (in legumes). 33

4. Breeding/screening and evaluation in sunflower, soybean, safflower for insect/disease resistance and high yield.

PULSES - TOTAL NO. OF SECTOR SCIENTISTS = 7

1. Breeding/screening pulse crop germplasm against disease resistance, high yield. 86

2. Disease identification and control. 71

3. Varietal trials. 43

FRUIT - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Evaluation of germplasm (local and exotic) for good quality, high yield. Plantation of new varieties. 75

2. Vegetative propagation. 25

3. Selection of promising lines/varieties for different ecological zones. 25

VEGETABLES - TOTAL NO. OF SECTOR SCIENTISTS = 8

1. Evaluation trials on vegetable germplasm (local/exotic) for adaptability, high yield and resistance to insects/pests. 50

2. Seed multiplication of promising material of winter and summer vegetables. 25

3. Growth regulator trials for enhancing yield and quality. 13

4. Identification and control of insect pests. 13

PLANT VIROLOGY - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Identification and characterization of plant viruses with special emphasis on those infecting solanaceous hosts. 100

2. Purification of viruses and production of antisera. 100

3. Screening crop varieties of sugarcane, potato and legumes for their resistance against important viruses. 25

4. Studies on the gemini viruses infecting legumes. 25

5. Development of the control of virus diseases in tomato, chillies, tobacco through protected nurseries. 25

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TISSUE CULTURE - TOTAL NO. OF SECTOR SCIENTISTS = 4

1.	Screening variants in rice and wheat by tissue culture.	100
2.	Micro propagation of date palm both with and without callus formation.	50
3.	Cleaning of virus free potato plants continues for supplying the material to the Northern areas.	50
4.	Standardization of callusing condition.	50

PLANT INTRODUCTION CENTRE - NO. OF SECTOR SCIENTISTS = 2

1.	Introduction of oil bearing plants and fruit plants.	100
2.	Commercial exploitation of tropical legumes at farmers field.	100
3.	Introduction of legumes germplasm of diverse origin for high yield, early maturing, disease resistance etc.	100

PLANT GENETIC RESOURCES - NO. OF SECTOR SCIENTISTS = 2

1.	Exploration and collection of crop genetic resources.	100
2.	Characterization and preliminary evaluation of crop germplasm for agro-morphological and genetic traits.	100
3.	Multiplication and supply of germplasm to the user community.	100
4.	Conservation/preservation of crop germplasm.	100
5.	Documentation of genetic resources informations.	100

ENTOMOLOGY - TOTAL NO. OF SECTOR SCIENTISTS = 10

1.	Control of insect pests by use of the insecticides, medicinal plant extracts, pheramones, cultural control.	60
2.	Collection of life table data, development of rearing techniques.	30
3.	Evaluation of plants for the insecticidal activity and identification of toxic chemical ingredients.	30
4.	Collection of literature on insect pests with a view to publish bibliography.	30

VERTEBRATE PEST CONTROL - NO. OF SECTOR SCIENTISTS = 2

1.	Rat population estimation in whole sale markets in big cities	100
2.	Reproductive biology of *Rattus rattus*.	100
3.	Evaluation of Anticoagulant pesticides against wild boar.	100
4.	Farmers training.	100

WEED - TOTAL NO. OF SECTOR SCIENTISTS = 6

1.	Biology and ecology of weeds.	50
2.	Control of weeds with chemicals and cultural practices. Evaluation of methods of herbicidal application.	50
3.	Weed-crop competition.	33

FODDER - TOTAL NO. OF SECTOR SCIENTISTS = 4

1.	Collection and introduction of superior exotic and indigenous fodder crops species/varieties. Breeding/screening for high fodder yielding, multicut, nutrition, disease and insect resistant varieties.	75
2.	Evaluation of the exotic and indigenous material of fodder crops.	50
3.	Testing/performance of different fodder crop varieties at high altitude in NWFP, Azad Jamu & Kashmir and Northern areas.	25
4.	Seed multiplication of selected, improved fodder crop varieties and their distribution.	25

CYTOGENETICS - NO. OF SECTOR SCIENTISTS = 3

1.	Alien genetic transfer in wheat	67
2.	Species introgression in *Brassica*.	33
3.	Intraspecific hybridization in *Vigna*.	33
4.	Cytogenetic studies of *Lathyrus* hybrids and wheat.	33
5.	Induction of seed sterlity in tea.	33

GRAIN STORAGE - NO. OF SECTOR SCIENTISTS = 2

1.	Resistance in stored grain pests to pesticides.	100
2.	To study the inherent suceptibility of rice, maize and wheat varieties against the stored grain insect pests during storage.	50

BARD - TOTAL NO. OF SECTOR SCIENTISTS = 10

1.	Collection, introduction, breeding and selection of local/exotic oilseed varieties (rape, mustard, groundnut) for high yield, double low characters, disease/insect resistance.	60
2.	Studies on application of fertilizers, herbicides and insecticides.	40
3.	Studies on different aspects of biological nitrogen fixation in legumes in barani area.	30

CDRI - TOTAL NO. OF SECTOR SCIENTISTS = 12

1.	Survey and identification of fungal diseases of cereals, oilseed crops, fruit & vegetables.	75
2.	Monitoring of virulence of wheat rusts in the country; identification of source of resistance against diseases.	67
3.	Biology of diseases and control by cultural practices, biological means and chemicals.	50

N&FQ - TOTAL NO. OF SECTOR SCIENTISTS = 8

1.	Provide analytical/screening services to breeders of oilseeds/ cereal legumes.	25
2.	Evaluation of the varietal differences in Pakistani and Canadian oilseed varieties.	25
3.	Evaluation of protein quality in pre-rain and post-rain harvested wheat varieties in experimental animals.	50
4.	Effect of processing on tannin content of some lentil and chickpea varieties.	25
5.	Effect of processing on phytate content of some commercial wheat varieties.	25
6.	Evaluation of the flatus producing factors in legumes.	13
7.	Nutritive value and physico-chemical characteristics of some legumes grown in Pakistan.	38
8.	Effect of different packing materials on nutritional quality of wheat flour.	38
9.	Establishment of methodology for extraction of sheera from dates being grown at Sukkhur and in Baluchistan.	25
10.	To evaluate maximum flour yield by giving different tempering and resting times to local wheat varieties.	25
11.	Determination of flour quality and flour quantity in different wheat varieties grown at various locations in the country.	13
12.	Effect of different fertilizer treatments on the quality of cereals and legumes.	25
13.	Evaluation of protein quality of various combinations of wheat flour and potato flour in experimental animals.	25

WHEAT - TOTAL NO. OF SECTOR SCIENTISTS = 4

1.	Germplasm acquisition, evaluation and distribution.	100
2.	National uniform testing program.	50
3.	PARC observation nursery.	50

LAND RESOURCES - NO. OF SECTOR SCIENTISTS = 17

1.	Studies on different aspects of N cycle (NH_3 Volatilization, NO_3 leaching, denitrification, biological nitrogen fixation, inoculum production etc.). Studies on BNF by Azola and Rhizobium - legume symbiotic systems.	35
2.	Evaluation of methods of application of fertilizers and plant/crop response. Soil test calibration for P.	24
3.	Estimation of macro- micro-nutrient status of soil.	24
4.	Soil P dynamics affected by organic mannure.	18
5.	Ascochyta life strategies, ecology and control.	12

SCAN - TOTAL NO. OF SECTOR SCIENTISTS = 1

1.	To know whether the soils within the same family have similar response.	100
2.	Development and testing of soil management practices.	100
3.	To monitor and assess soil moisture relationship with crop yield.	100
4.	Soil characterization ie. soil identification and profile description of experimental sites for wheat experiments.	100

STRESS PHYSIOLOGY - NO. OF SECTOR SCIENTISTS = 2

1.	Physical aspects of chickpea cultivation.	100
2.	Physiology and biochemistry of sugarbeet and fooderbeet under stress environment.	100
3.	Role of biochemical markers on physiology of wheat and rice under saline environment.	100
4.	Regulation of some key enzymes of plant systems responsible for yield potential under stress conditions.	100
5.	Reproductive physiology of crop plants under salt stress.	100

RANGE & WATERSHED - NO. OF SECTOR SCIENTISTS = 8

1.	To study the effect of grass-legume mixture on forage yield and quality.	50
2.	To study the effect of N & P fertilizers and row spacing on forage yield, protein content and nitrogen fixation.	50
3.	To find out the effect of trees on agricultural crops.	13
4.	Determination and delineation of forage potential in various agro-ecological zones of Pothowar.	13

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REMOTE SENSING - NO. OF SECTOR SCIENTISTS = 2

1.	A study of spectral reflectance properties of maize and wheat crops.	100
2.	Construction of simulation models for predicting the best times of sowing and harvest of cereal crops.	50

WATER RESOURCES - NO. OF SECTOR SCIENTISTS = 9

1.	Development of different moisture conservation/utilization techniques for increased crop production under different set of conditions.	56
2.	Collection of agro-met data and development of relationship between weather elements.	44
3.	Monitoring of surface run off and soil loss as affected by different crop rotations and methods of sowing.	44

SERICULTURE - NO. OF SECTOR SCIENTISTS = 1

1.	Rearing 3rd generation of silkworm at NARC.	100
2.	Effect of potassium iodide on larval life and silk production.	100
3.	Effect of pruning on production of foliage of 7 exotic varieties and 3 species of mulberry, in order to get regular supply of foliage during Nov-Dec.	100

HONEYBEE - NO. OF SECTOR SCIENTISTS = 4

1.	Improvement of *Apis mellifera.*	100
2.	Production of honeybee venom.	100
3.	Efficacy of chemotherapeutic agents for the control of hornets (*Vespa* spp.)	100
4.	Selective breeding of *Apis mellifera* for propolis production.	75
5.	Biometric studies and distribution map of *Apis* spp.	75
6.	Effect of bee pollination on yield and oil contents of sunflower.	75
7.	Additional nectar and pollen sources for honeybees.	75
8.	Biology and control of *Tropilaelaps clareae*, *Varroa jacobsoni* and *Acarapis woodi*.	50
9.	Effects of honeybee pollination on yield of watermelon (*Citrullus lanatus*).	50

ANIMAL SCIENCES INSTITUTE

REPRODUCTIVE PHYSIOLOGY - NO. OF SECTOR SCIENTISTS = 4

1.	Studies on superovulation and endocrime response with FSH in cows and buffaloes.	50
2.	Studies on embryo transfer in indigenous goats. Freezing of bovine embryos.	50
3.	Factors affecting post-partum reproductive performance in buffaloes.	25
4.	Effect of nutrition on the growth rate and age at puberty in buffaloe heifers.	25
5.	Influence of harmones and energy levels on the induction of puberty in buffaloe heifers.	25
6.	Early pregnancy diagnosis by the estimation of plasma progestron in buffaloes.	25

DAIRY CATTLE & CROSS BREEDING - NO. OF SECTOR SCI. = 3

1.	Adaptability of Jersey cows to local environmental conditions.	67
2.	Out reach program on dairy cattle cross breeding in Islamabad Capital Territory, FSR Program in Fateh Jang and Chakwal areas.	33
3.	Evaluation of buffaloe herd at ASI. Cause of calf mortality.	33

GOAT PROJECT - NO. OF SECTOR SCIENTISTS = 1

1.	Working on projects "comparative studies on growth and carcass traits of different breeds of goats" and coordinated research project on improvement of goats.	100

MEAT TECHNOLOGY - NO. OF SECTOR SCIENTISTS = 1

1.	Comparative studies on growth, carcass traits; meat characteristics and quality of beef from cattle and buffaloes raised under feed lot.	100

SHEEP & WOOL - NO. OF SECTOR SCIENTISTS = 2

1.	Evaluation of economic traits of different breeds of sheep. Studies on the follicle population of the different breeds of sheep.	100
2.	Introduction of Rambovillet genes to local breeds of sheep in order to augment live weight and fleece weight.	50

FISHERIES - NO. OF SECTOR SCIENTISTS = 4

1.	Fingerling rearing in earthen tanks on supplementary feeding.	25
2.	Management of broodstock and induced spawning trails using various combinations of harmones.	25
3.	Monitoring growth rate of fish.	25
4.	Study of factors affecting the population dynamics.	25
5.	Evaluation of existing fresh stock with special emphasis on species, composition, sex ratio, age and size distribution of Rawal Lake.	25
6.	Survey of fresh water prawns in and around Islamabad.	25

POUNTRY - NO. OF SECTOR SCIENTISTS = 2

1.	Comparative productive performance of eight layer breeds.	100

ANIMAL HEALTH - NO. OF SECTOR SCIENTISTS = 6

1.	Investigation of pathogenesis and pathology of Haemmorrhagic Septicaemia in cattle and buffaloes.	17
2.	Improvement and development of effective vaccine against Haemmorrhagic septicaemian cattle and buffaloes.	17
3.	Investigation of etiology, clinical test and treatment of sub-clinical mastitis in buffaloes and cows.	17
4.	Investigation of etiology and treatment of calf diorrhaea/ calf mortality.	17
5.	Characterization of Glycoprotein of Newcastle disease and evaluation as a subunit vaccine.	17
6.	Studies on the carrier status of Pastevrellae in cattle and buffaloes.	17
7.	Prevalence of endo and ecto parasites (ASI & Barani Area).	17

ANIMAL NUTRITION - NO. OF SECTOR SCIENTISTS = 6

1.	Varietal differences in the nutritive value of wheat and rice straws.	67
2.	Feeding of urea molasses blocks to ruminant under various farming systems.	33
3.	Study of starch urea products designed for slow N-release and their technology development.	33
4.	Improving the nutritive value of crop residues through various physico-chemical and biological treatments.	67
5.	Studies on the nutritive value of various types of silages.	33

TRAINING INSTITUTE - NO. OF SECTOR SCIENTISTS = 4

1. Planning, organization and evaluation of training courses. 100

2. Tailored the course evaluation questionnaire and studied the impact of several training courses. Also tailored questionnaire to know the impact of farmers training program initiated for the farmers of Islamabad Capital Territory. 25

3. Bring out annual report of Training Institute in respect of all the courses conducted during the year and this report is based on the scientifically tailored questionnaire. 25

FMI - TOTAL NO. OF SECTOR SCIENTISTS = 10

1. Development, evaluation and improvement in locally manufactured/imported farm machines (sugarcane planter, threshers, forage mover, multicrop drill, weeding tools etc.). 100

COMPUTER & STATISTICS - NO. OF SECTOR SCIENTISTS = 3

1. To determine the optimum number of sampling units and size for weed density estimation. 33

2. To investigate the effect of weeding frequency and sampling time on rice grain yield. 33

3. Stability analysis on soybean and cluster analysis on sorghum data. 33

4. Payroll accounting on computer and statistical analysis. 33

PUBLICATION AND SCIENTIFIC INFORMATION - NO.OF SECTOR SCI.= 5

1. Union list of journals (compilation). 20

2. Computerization of data base. 20

3. Micro filming of research information materials and administrative records. 20

4. Input to AGRIS system, their collection, indexing, classification, computerization etc. 20

5. Bibliographic service based on AGRIS data base. SDI service based on AGRIS data base. 20

6. Document delivery service. 20

AERU - NO. OF SECTOR SCIENTISTS = 4

1. Factors affecting cropping pattern and cropping intensities in Barani areas. 75

2. Crop-livestock interaction in Barani area. 50

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3. Economics of weedicide use in Islamabad Capital Territory. 50

4. Production and marketing of milk in Barani area. 50

5. Economics of wheat and mustard inter-cropping. 25

6. Economic analysis of fertilizer response for wheat in Barani area. 25

List below your specific Research Plans for next 5 years.

RICE - TOTAL NO. OF SECTOR SCIENTISTS = 4	Percent*
1. Selection/breeding local and exotic rice for high yield and insect resistance.	= 75
2. Evaluating rice quality parameters (Protein, milling and cooking).	= 25
3. Effect of storage conditions on rice quality	= 25
4. Rice re-classification based on physical/chemical properties.	= 25

MAIZE - TOTAL NO. OF SECTOR SCIENTISTS = 3	
1. Development of early (borer resistant) maize varieties for highlands that is drought and cold tolerant.	= 67
2. Screening for insect pest resistance (stem borer)	= 35
3. Control of insect pest (pheramones & parasites).	= 33
4. Economics of growing maize crop and fodder maize.	= 33

SORGHUM & MILLET - TOTAL NO. OF SECTOR SCIENTISTS = 2	
1. Introduction, hybridization and selection against drought and heat stress and early maturity.	= 100
2. Farm fertility, density, weed control and short fly - stem borer trials.	= 100

SUGAR - TOTAL NO. OF SECTOR SCIENTISTS - 1	
1. Establishment of Quarantine Nursery and sugarcane laboratory with a sugarcane breeding institute.	= 100
2. Selection of sugarcane varieties for high yield, high sucrose content, and resistance to disease and pests, frost resistant, tolerant to drought and useful for problem soils.	= 100
3. National uniform variety yield trials.	= 100%
4. Selection of site for production of good quality seed of sugar beet.	= 100
5. Post harvest losses in yield and sucrose content of sugar beet.	= 100

*Refers to the percent of of sector scientists who agree with the given statement.

ADDENDUM TO Q-5

VEGETABLE - NO. OF SECTOR SCIENTISTS = 7

1. Transfer of virus resistance and high salt tolerance to L.esculentum cv. "Roma".

2. Heterosis and combining ability studies between 10 - 15 inbred lines to select better combiners so as to utilize them in F_1 hybrid seed production.

3. Transfer of disease resistance from exotic germplasm to the local cultivars of muskmelon and P. sativum "Meteor" & "Green Feat".

4. Identification and transfer of resistance to the virus causing "smalling of leaves" in chillies Capsicum frutescens. Search for heat and drought tolerant cultivars of bell pepper Capsicum annum for cultivation in hotter areas of Pakistan.

5. Import of common bean (Phaseolus Vulgaris L.) germplasm from CIAT to select stress tolerant cultivars suitable for our climate. Cytological verification of extra chromosome in four trisomics of common bean (Phaseolus vulgaris L.) by Geimsa staining technique. Search for the remaining trisomics among the progeny of translocation deterozygotes developed from homozygous translocation stocks in common bean (Phaseolus vulgaris).

6. Search for heritable somachonal variations in tissue culture of Tomato.

7. Induced mutations in tissue culture and their characterization at chromosomal level.

OILSEED - TOTAL NO. OF SECTOR SCIENTISTS = 6

1. Breeding/selection in sunflower, soybean, safflower, sesane, for insect/disease resistant (char coal rot, heat rot and stem blight), and high yield, high oil content, early maturing and non-shattering. = 83

2. Selection of promising lines for different ecological zones. = 33

3. Develop rapeseed - mustard - pest (insect) system models = 17

PULSES - TOTAL NO. OF SECTOR SCIENTISTS = 7

1. Breeding/selection varieties for disease resistant, high yielding, early and synchronous maturity, root nodulation for agro-ecological sub zones. = 86

2. Disease identification and integrated pest control for chickpea blight, root rot/wilt, moongbean yellow mosaic virus, cercospora leaf spot. = 71

FRUIT - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Evaluation of germplasm (local and exotic) for high yield and sequential maturity (peaches, pears, apricot, grapes, pomegranate, plum, citrus, guava and laquat). New crops (olive, kiwi, black berry, raspberry and cherry). = 100

2. Vegetative propagation techniques (grafting, stem-cutting etc.). Use of growth regulators for maturity, fruit drop and flowering. = 100

3. Fertilizer studies on fruit. = 25

4. Selection of promising lines/varieties for different ecological zones. = 25

VEGETABLE - TOTAL NO. OF SECTOR SCIENTISTS = 7

1. Evaluation of germplasm for adaptability, high yield, better quality and resistance to insects/pests, heat tolerance and for off season crops under special ecological conditions. = 43

2. Seed multiplication harvesting, post harvest maturation, storage, threshing and cleaning of seeds of root crops. = 43

3. Use of growth regulating substances for high yield and better quality. = 14

4. Cropping systems studies with vegetables or other inter-cropping and development of Home Gardens. = 14

5. Identification and control of insect pests of vegetables and fruits. = 14

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ITALIAN PROJECT FOR FRUITS & VEGETABLES - TOTAL NO.OF SECTOR SCI. = 1

1. Evaluation of different species of desiduous and olive trees with different localities and climatic conditions. = 100

2. Comparison of different cultural and management practices in desiduous and olive orchards. = 100

3. Comparison of different methods of propagation. Effect of different times and methods of pruning on vegetative and reproductive growth of desiduous trees. = 100

4. Effect of harmones and growth regulators on ripening stage, fruit size and quality. = 100

PLANT VIROLOGY - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Purification of viruses and production of antisera, Elisa kits for potato, sugarcane, citrus, pulse crop, fruit & vegetable viruses. = 100

2. Studies on monoclonal antibodies and nucleic acid spot hybridization. = 75

3. Symptomology, host range, transmission and control of important virus diseases. = 75

4. Epidemiology of gemini viruses. = 50

5. Publication, pamphlets, bulletins, seminas. Training and development of manpower. = 50

TISSUE CULTURE - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Development of an efficient collogenic and regeneration system specific for Basmati lines of rice. Use of somaclones as useful lines for breeding program/direct cultivation. = 75

2. Standardizing techniques for an efficient regeneration system from cell suspension culture in both rice and wheat. Selection for stress tolerance in labs./field. = 50

3. Attempting protoplast/anther, pollen (haploid) culture in cereals (rice, wheat) to be utilized for genetic engineering. = 50

4. Standardizing efficient micro propagation system in date palm. = 50

5. In vitro tuber production in potato and supply of virus free potato. = 25

PLANT INTRODUCTION CENTRE - TOTAL NO. OF SECTOR SCIENTISTS = 2

1. Introduction, documentation, maintenance, evaluation and multiplication of high economic value plants and distribution under various agro-climatic conditions. = 100

2. Introduction of dry zone, hard wood species for arid and marginal lands in the country. = 50

3. Identification of cultivars in germplasm collections using polyacrylamide gel electrophoresis. = 50

4. Cryopreservation of apical meristen of fruit germplasm. = 50

PLANT GENETIC RESOURCES - TOTAL NO. OF SECTOR SCIENTISTS = 2

1. Exploration, collection, maintenance, evaluation, conservation of endangered crop species (rice, chickpea, millet and sorghum, forage, medicinal plants) in the gene bank and utilization in crop improvement program. = 100

2. Effect of temperature and moisture on seed viability of cereals, legumes and oilseed crops. Monitoring seed viability of the conserved stock in the gene bank. = 100

3. Documentation of genetic resources informations and supply of germplasm to the national and international research institutes. = 100

ENTOMOLOGY - TOTAL NO. OF SECTOR SCIENTISTS = 10

1. Control of insect pests: by use of the insecticides, medicinal plant extracts, cultural control methods, pathogenes (eg. B.T.), light traping, natural enemies (predators and parasites), pheramones. = 100

2. Development of population sampling methods and collection of life table data. Determination of the factors regulating population of the various insect pests of sugarcane, rice, vegetable and fruits. Suitable methods for scouting, forecasting and prediction will be found out. = 50

3. The effect of selected insecticides on the potential natural enemies. Persistence/bio-degradation of insecticides. = 50

4. Publication of anotated bibliographics based on world-wide literature. = 40

5. Evaluation of different varieties of crops for pest resistance. Study of enzymatic basis of insect resistance. = 30

6. Estimation of losses of various crops caused by insect pests. = 10

VERTEBRATE PEST CONTROL - TOTAL NO. OF SECTOR SCIENTISTS = 2

1. Vertebrate pest (rodent, wild boar, birds, lagomarphs) control using poisons, traps, reflection tapes etc. = 100

2. Effect of diet and seasonal variation on reproductive glands of Bandicota bengalensis in rainfed areas. = 100

3. Estimation of pre- and post harvest losses. = 100

4. Field demonstration of various methods of vertebrate pest control and extension staff training. = 100

WEED - TOTAL NO. OF SECTOR SCIENTISTS = 6

1. Evaluation of different methods of weed control eg. weedicides, biological, mechanical, cultural practices in maize, wheat, rice, vegetable, fruit, cotton etc. = 83

2. Biological and ecology of important weeds of different ecological zones. = 50

3. To study the effect of herbicide on weeds, crop plant and soil micro flora. Persistence of herbicides. = 50

4. Improving weeding tools. = 17

FODDER - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Collection, introduction, evaluation of germplasm (local/exotic) for superior fodder species/varieties with high yield, lodging resistant, drought, disease/insect resistant, tolerant to salinity and water logging etc. Preliminary screening, hybridization (eg. sorghum - Sudan grass) and selection under different ecological conditions. = 50

2. Demonstration trials = 50

3. Integration of fodder crops with livestock production in the farming systems. Evaluation of nutritive value of fodder crops/varieties. = 50

4. Multiplication of seed of improved fodder crops/varieties and its distribution. = 25

CYTOGENETICS - TOTAL NO. OF SECTOR SCIENTISTS = 3

1. To transfer disease resistant and stress tolerant genetic material into wheat from widely related species. = 100

2. To develop Brassica lines with non shattering, applied resistance and high quality oil characteristics. = 33

3. To develop disease resistant pulses. = 33

4. To evolve multiple harvesting grass pea and toxin free Khasari dal. = 33

5. To induce seed sterlity in tea. = 33

GRAIN STORAGE - TOTAL NO. OF SECTOR SCIENTISTS = 2

1. Resistance in stored grain pests to pesticide (eg.Malathian and Phosphene). = 100

2. Testing various IMP protocols in public sector storage. Training of food department officials to reduce storage losses. = 100

3. Ecology of storage losses in major food grains (rice, wheat, maize). = 50

BARD - TOTAL NO. OF SECTOR SCIENTISTS = 11

1. Studies on application of fertilizers, herbicides and insecticides. = 55

2. Collection, introduction, breeding and selection of local/exotic oilseed varieties for high yield, early maturity, double low characters disease/insect resistant. = 45

3. Develop strong linkages between farmers, crushers and processors (edible oil industries). Transfer of technology to farmers and Provincial scientists. = 45

4. Assessment of macro and micro nutrient status of soils of different localities of barani areas and response of applied nutrients. = 18

5. Studies on different aspects of biological nitrogen fixation in legumes (groundnut, chickpea, forage legumes) in barani area. Beneficial effects (residual fertilizer effect) of legume (groundnut) on subsequent cereal crops. = 18

6. Modification and use of equipments (threshing, sowing etc.) and training to scientific and field staff. Suggestion and guidance to farm machinery manufacturers. = 9

7. Socio-economic constraints of Barani farmers. = 9

CDRI - TOTAL NO. OF SECTOR SCIENTISTS = 12

1. Identification of sources of resistance against diseases and provide the seed to the provincial breeders for evolution of rust resistant cultivars. Incorporation of new sources of resistances in cultivars. = 58

2. Identification of physiologic races of rusts and analysis of virulence present in the natural population of rust pathogen. = 33

3. Survey and identification of important fungal and other diseases of cereals, oilseed, fruits and vegetables. = 17

4. Control of diseases by cultural practices, biological means or chemicals (fungicides, nematocides etc.). = 8

5. To monitor the occurrences and spread of potato cyst nematodes in potato growing and seed production areas. Screening of potato varieties/clones for resistance against PCN. Identification of pathogenes on PCN. = 8

FOOD TECHNOLOGY - TOTAL NO. OF SECTOR SCIENTISTS = 8

1. Effect of production environment on the nutritional quality of cereals. = 75

2. Effect of storage on the quality of food grains. = 75

3. Antinutritional factors in cereals/legumes & oilseeds = 63

4. Pesticide residues in cooked food products and the possible interaction of the residues with different spices under local cooking conditions. = 50

5. Study of the nutritive value and consumer acceptance of salicornia oil. = 50

6. Screening of germplasm/early/advance lines/varieties for protein content/nutritional quality/consumer acceptance. = 38

7. Improving the quality of bread and to have more bread from less wheat. = 38

8. Trace element content of local foods and diets. = 38

9. Improving the digestibility of food legumes. = 38

10. Development of new food products from soybean. = 25

WHEAT - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Evaluation of germplasm from local/exotic sources with an aim to advance most promising lines according to specific and defined set of objective. National uniform testing programe as continue process. = 100

LAND RESOURCES - TOTAL NO. OF SECTOR SCIENTISTS = 17

1. Response of different crops to fertilizers. Estimattion of critical levels of macro and micro nutrients for major crops of the country. Development of integrated plant nutrient system for various cropping system. = 59

2. Studies on different aspects of N cycle (amonia volatilization, NO_3 leaching, denitrification, biological nitrogen fixation). Studies on BNF by Azola and Rhizobium - legume symbiotic systems. = 29

3. Mapping of soils in relation to their fertility status. Calibration of soil tests. = 24

4. Ascochyta ecology, interaction with phylloplane micro flora, biological control and development of residual-effect free fungicide. = 12

5. To study life strategies of micro organisms important in bio-technology (enzyme/antibiotic production). = 12

6. To find out suitable sources of micro nutrients, amount required for different crops, storage and methods of application under control as well as under field conditions. = 6

7. Assessment of sulphur content in soils, inflow with irrigation water, rain, dust etc. and outflow with drainage water. Identification and use of local sources of sulphate/sulphue. = 6

8. Availability, nutrient status and effect on physical properties of soils of various organic materials/organic manure (crop residues, animal droppings, urban wastes and factory by-products. = 6

9. Comparison and improvement in methods (biological, chemical) of reclamation of salt affected soils (sodic and saline sodic) and study of optimum requirement of fertilizers in these soils. = 6

10. Introduction and screening of salt tolerant plants for bio-mass production. = 6

11. To study mechanism of salt tolerance in plants and plant adaptations to salt stress. = 6

12. Studies on physical conditions in relation to soil moisture and nutrient dynamics. = 6

13. Identification of unknown compounds and structure illucidation by X-ray differaction machine. = 6

SCAN - TOTAL NO. OF SECTOR SCIENTISTS = 1

1. Development of crop yield prediction model for maize and wheat crops. = 100

2. Refinement of soil classification in such a way as to serve as a base for agro-technology transfer. = 100

3. Study various micromorphological phenomena as to understand various problems/constraints in soil which are restricting potential of soil. = 100

4. Study soil strength relationship with various factors of crop production. = 100

STRESS PHYSIOLOGY - TOTAL NO. OF SECTOR SCIENTISTS = 2

1. Determine the influence of salt and other stresses on pollen viability, germination etc. on cultivars of different tolerance and ion discrimination capacity. = 100

2. Establishment of markers, bio-chemical or biological for tolerance of these phases of the growth cycle to initially salt but also other environmental stresses for use as screening criteria. = 100

3. Determination of source/sink relationship related to grain fill under stress conditions as above. = 50

4. Investigate the proposed role of harmones ethylene and ABA in the stress tolerance at the reproductive grain filling phases of wheat/rice cultivars. = 50

5. Some important enzymes related to grainfilling and nitrogen assimilation wili also be studied in developing wheat/rice grains at mid milky stage (eg. a 1-4 glucangglucosyl transferases, Nitrate Reductase and Nitrite Reductase). = 50

6. Identify and characterize higher plants having high photosynthetic rate. = 50

7. Give necessary informations to breeders about salt tolerant characters of selected plants. = 50

RANGE & WATERSHED - TOTAL NO. OF SECTOR SCIENTISTS = 8

1. Testing suitable cropping system for different range-ecological zones. To select and introduce superior local/exotic forage species for different quality of rangelands. = 63

2. Develop winter forages for deficient period. Hay and silage making to preserve the forage. Quality evaluation trials. Livestock digestibility and performance value. = 38

3. To study the effect of intercropping of various grass-legume combinations to establish the perenial pasture. To introduce forage and pasture legumes to rangelands for Nitrogen Fixation to improve soil conditions. = 38

4. The effect of grazing and grazing management on run off, erosion and vegetation composition. = 38

5. Develop model for commercial ranching. = 25

6. Fertilizer trials on various forage crops. = 25

7. Planting of recommended multipurpose tree species on farmers field. To establish block plantations of fast growing species for farm-forestry purpose. = 13

8. To investigate the effect of forage tree/shrubs on forage legumes and grasses (silvo - pasture trials). = 13

9. Effect of trees, crops and engineering structures on run off and erosion. To assess suitability and effectiveness of selected trees for watershed protection and improving productivity. = 13

10. Agro-ecological zonation of crop suitability in different areas (Gujranwala, Gujrat, Sialkot, Jhelum, Chakwal, Peshawar, Bannu, Abbottabad districts). Soil maps will be prepared. = 13

REMOTE SENSING - TOTAL NO. OF SECTOR SCIENTISTS = 2

1. Establishment of a remote sensing application unit at NARC = 100

2. To study the spectral reflectance properties of maize and wheat crop at various stages of growth and development. = 50

3. To establish a data base for deciphering satellite radiometer data for monitoring maize and wheat crops on a large scale. = 50

4. To formulate a suitable model for prediction bio-mass production/yield of maize and wheat crops. = 50

WATER RESOURCES - TOTAL NO. OF SECTOR SCIENTISTS = 9

1. Development of different moisture conservation and utilization techniques under different set of conditions. Development of portable low cost sprinkler irrigation. To make trickle irrigation system useable by farmers for economic crop production in water scarce areas. = 78%

2. Evaluation of different soil/crop management practices for surface run off and soil loss control. Effect of different vegetation and mechanical treatments on the run off and soil loss. = 56%

3. Data collection on rain fall/run off and soil losses under different set of conditions to provide data base for prediction models. = 44%

4. Modelling of soil fertility losses through erosion and decrease in crop yields. = 33

5. Development of integrated land use models under different ecological zones. = 22

6. Development of erosivity/erodibility maps of the erosion areas for conservation planning. = 11

SERICULTURE - TOTAL NO. OF SECTOR SCIENTISTS = 1

1. Establishment of pure lines of silkworm. = 100

2. Chemicals, radiation and harmones will be used to develop strains of silkworm suitable for different climates, with better quality silk and maximum production. = 100

3. Silkworm and production unit will be established at NARC = 100

4. By inbreeding mulberry varieties better strains will be developed having better yield and more nutritive value. = 100

HONEYBEE RESEARCH PROGRAM - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. The potential researchable areas for the hive bees (*A. cerane* and *A. mellifera*) and the rock bee (*A. dorsata*) include management, disease, breeding, crop pollination, floral sources, domestication of rock bees and honey processing.	=	75
2. Effect of bee pollination on fruit plants and oilseed crops.	=	50
3. Training to villagers and short notes in regional languages on "management of bee colonies".	=	25

ANIMAL SCIENCES INSTITUTE - TOTAL NO. OF SECTOR SCIENTISTS = 29

A- REPRODUCTIVE PHYSIOLOGY - NO. OF SECTOR SCI. 4

1. To study the mechanism of superovulation. Developing a superovulatory regime for local sheep, goats and buffaloes. = 75

2. To develop non-surgical embryo transfer in buffaloes, cryo preservation of bovine embryos, micro-surgery of embryos, sexing of embryo, invitro fertilization. = 75

3. To study the bio-chemical properties of buffaloe semen = 25

4. To develop a suitable extended for the preservation of buffaloe semen and to increase its fertilizing ability. = 25

5. To identify the causes of poor quality semen in cross-bred cow bulls and to enhance the conception rate in cross-bred cows by improving the quality of semen. = 25

6. To reduce the age at puberty in buffaloe heifers. = 25

7. Study on endocrinology of buffaloes. = 25

B- DAIRY CATTLE & CROSS BREEDING - NO. OF SECTOR SCI.= 1

1. Continuation of the out reach dairy cattle cross breeding program in Islamabad Capital Territory. = 100

2. Performance evaluation of the Jersey herd maintained at Animal Sciences Institute. = 100

C- GOAT PROJECT - TOTAL NO. OF SECTOR SCIENTISTS = 1

1. Work on: i) Coordinated research project on improvement of goats. = 100

ii) Comparative studies on growth and carcass traits of different breed of goats. = 100

iii) Selection of high producing dams for embryo transfer in Jersey herd. = 100

D- MEAT TECHNOLOGY - TOTAL NO. OF SECTOR SCIENTISTS = 1

1. Beef and mutton production capabilities of different categories of local livestock ie. cattle, buffaloe, sheep and goats. = 100

2. Pre-slaughter and post-slaughter factors affecting quantity and quality of meat. Studies on the effective utilization of slaughter house wastes and by-products. = 100

E- SHEEP & WOOL - TOTAL NO. OF SECTOR SCIENTISTS = 2

1. To bring about the desired level of improment in quantity and quality of carpet wool and mutton production potential of sheep through selection of cross-breeding.	=	100
2. Studies on the productive and reproductive traits for evaluation of production potential of sheep.	=	50
3. Determination of the nutritional requirements - maintenance and production.	=	50
4. Study on wool characteristics.	=	50
5. Utilization of agro-industrial by-products for sheep production.	=	50
6. To investigate and control the specific sheep diseases which affect production ability.	=	50

F- FISHERIES - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Assessment of carrying capacity of water reservoirs, running waters.	=	50
2. Fresh water prawns aquaculture at farm level and establishment of fresh water prawn hatchery.	=	50
3. To develop and standardize techniques for induced breeding of fish. Genetic improvement of carps through hybridization and/or sex reversal techniques.	=	25
4. To formulate supplementary feed formulae based on cheap and locally available feed ingredients.	=	25
5. Strain selection for rapid growth rate, better reproductive performance, hardiness, feed conversion efficiencies and high dress out percentage.	=	25

G- POULTRY - TOTAL NO. OF SECTOR SCIENTISTS = 2

1. Identification of high producing, adaptable strain/ strains of commercial broilers and layers introduced in Pakistan.	=	100
2. Poultry management system for different areas and conditions.	=	100
3. Evolving of new poultry strain suitable for villages in scavenging conditions.	=	50

H- ANIMAL HEALTH - TOTAL NO. OF SECTOR SCIENTISTS = 6

1. Development of monoclonal antibodies for diagnostic purposes especially against foot & mouth disease virus for serotyping and subserotyping. = 50

2. Development of immunohistochemistry techniques for diagnosis of major livestock diseases. = 33

3. Improvement of Haemorrhagic septicaemia vaccine through inclusion of adjuvants and subcellular components and evaluation of a combined vaccine for Haemorrhagic septicaemia and foot & mouth disease virus. = 33

4. Investigation of etiology and control of contagious pleurophenumonia in sheep and goats. = 33

5. Studies on thieleriasis in cattle and buffaloes. = 33

6. Development of subunit vaccine against Newcastle disease virus in poultry. Improvement of vaccine through genetic engineering. = 17

I- ANIMAL NUTRITION - NO. OF SECTOR SCIENTISTS = 6

1. Improving the nutritive value of crop-residues and industrial by-products and wastes through various physico-chemical and biological treatments. = 67

2. Manipulation of the rumen eco-system for maximum utilization of unconventional feed resources. = 50

3. Development of suitable technologies to produce solidified multinutrient urea molasses blocks, feed blocks, briquettes, pellet etc. designed for diverse ecological farming systems. = 33

4. Testing of different by-pass proteins, deworming agents, hardning agents, fillers and levels of common salts in blocks. = 33

5. Studies on the technical feasibility and economic viability of integrated recycling systems (Broiler-Dairy-Biogas-Fish). = 33

6. Development of economical and feasible feedlot system for increased mutton and beef production based on complete least cost rations. = 17

7. Development of efficient and economical processing methods for the utilization of poultry litter and animal wastes in livestock feeding. = 17

8. Establish the nutrient requirements of various classes of livestock, including drought animals. = 17

TRAINING INSTITUTE - TOTAL NO. OF SECTOR SCIENTISTS = 4

1. Conduct seminars/conferences on various issues in high agriculture education and collaborate with international institutes. = 75

2. Monitor and evaluate Training Institute courses and adoption by farmers of improved technology. = 50

3. Develop in-service training of middle and senior level manpower engaged in the field of agriculture and related support services. = 50

4. Coordinate NARC research with Post Graduate University Thesis studies. = 50

5. Establish development courses for new research system recruits. = 25

AGRICULTURAL ECONOMICS RESEARCH UNIT - NO. OF SECTOR SCI. = 4

1. Comparative economics of various cropping systems and soil management/conservation practices of barani areas. = 100

2. Investigate the comparative production and marketing economics of selected commodities. = 100

3. Investigate employment and income generating alternatives with farmers risk management in barani areas. = 100

PUBLICATION & SCIENTIFIC INFORMATION - NO. OF SECTOR SCI. = 5

1. Catalogue and computerize information for PARC Bibliographic Data Base and AGRIS and CARIS services with major provincial agricultural libraries. = 80

2. Operate on-line search technology with international data-bases and establish on-line search facilities between PARC and provinces. = 60

3. Strengthen microform and video section of NARC Library with related photographic services and manpower development. = 60

COMPUTER & STATISTICS - NO. OF SECTOR SCIENTISTS = 3

1. Advise relative to field plot techniques, plot sampling, cluster and principal component analysis and use of ANOVAS for GXE analysis. = 67

2. Collaborative research on dynamics of different insects, weed and other pests. = 67

3. Development of crop yield and forecasting models stability of cultivars. Installation and operation of SAS package. = 33

4. Develop the response surface approach to determine optimum levels of fertilizer on all major crops. = 33

5. Improve computerized management of personnel information to tailor statistical softwares and payroll accounting and related mini data bank. = 33

FARM MACHINERY INSTITUTE - NO. OF SECTOR SCIENTISTS = 10

1. Development, evaluation and improvements in locally manufactured/imported farm machines. = 60

2. Local manufacture of farm machinery and commercialization. = 60

3. Study of feasibility of sprinkler system in dry direct seeding of rice, development and commercialization of dry direct seeding of rice cultivation technology. = 20

4. Selection of optimum machinery packages for various farm systems and cropping pattern. = 10

5. Association in establishment of "Testing Lab.", using and minor repair of instruments. = 10

6. Design and fabrication of green houses. = 10

7. Conducting national training courses on testing and evaluation of agricultural machinery. = 10

RESEARCH MANAGEMENT ITEMS

ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Circle a response for each statement according to the following scale:-

A : Strongly agree;
B : Agree somewhat;
C : Undecided;
D : Disagree somewhat;
E : Strongly disagree.

NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	Agree %	Disagree %	Undecided %
1.	Inadequate facilities preclude quality research.	54	39	6
2.	Lack of reward for performance retards achievement of research excellence.	64	23	14
3.	Scientists should put more effort into seeking what research be conducted.	97	2	2
4.	Internal Research Reviews encourage scientists to keep research content abreast.	91	4	4
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	71	16	14
6.	In general laboratories are adequate for research.	74	15	11
7.	The library resources and services are adequate for research.	57	37	7
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	37	48	15
9.	Procurement procedures and practices ensure supplies and equipment on time.	19	70	12
10.	Operational funds for research are adequate and provided on time.	34	50	15
11.	Methods of allocating research resources to projects and individuals are satisfactory.	45	37	17
12.	My research is successfully integrated and coordinated with other institution scientists.	76	11	14
13.	Staff members at my level have an adequate voice in planning and conducting research.	59	29	12
14.	Unit Committees, meetings and other means provide for adequate communication.	82	6	12
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	81	9	11
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	36	33	30

TOTAL NO. OF SCIENTISTS RESPONDED - 207

NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	12	47	6	22	13
2.	Lack of reward for performance retards achievement of research excellence.	24	41	17	8	10
3.	Scientists should put more effort into seeking what research be conducted.	79	20	1	--	2
4.	Internal Research Reviews encourage scientists to keep research content at least.	61	31	4	2	1
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	24	44	14	17	7
6.	In general laboratories are adequate for research.	30	45	13	9	3
7.	The library resources and services are adequate for research.	14	42	5	23	16
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	8	27	19	33	16
9.	Procurement procedures and practices ensure supplies and equipment on time.	4	17	13	23	44
10.	Operational funds for research are adequate and provided on time.	10	24	16	32	18
11.	Methods of allocating research resources to projects and individuals are satisfactory.	9	39	19	23	9
12.	My research is successfully integrated and coordinated with other institution scientists.	30	47	13	10	1
13.	Staff members at my level have an adequate voice in planning and conducting research.	25	33	[illegible]	16	11
14.	Unit Committees, meetings and other means provide for adequate communication.	47	37	10	3	3
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	55	29	9	6	2
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	13	26	34	13	15

TOTAL NO. OF SCIENTISTS RESPONDED = 135 (SOs)

NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	7	40	5	18	25
2.	Lack of reward for performance retards achievement of research excellence.	24	42	7	18	9
3.	Scientists should put more effort into seeking what research be conducted.	78	20	--	2	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	56	31	5	4	2
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	27	44	15	11	4
6.	In general laboratories are adequate for research.	36	36	11	16	--
7.	The library resources and services are adequate for research.	9	47	9	24	11
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	7	33	9	25	25
9.	Procurement procedures and practices ensure supplies and equipment on time.	7	11	13	24	45
10.	Operational funds for research are adequate and provided on time.	7	31	9	27	20
11.	Methods of allocating research resources to projects and individuals are satisfactory.	11	25	15	33	15
12.	My research is successfully integrated and coordinated with other institution scientists.	42	31	16	4	5
13.	Staff members at my level have an adequate voice in planning and conducting research.	25	35	4	18	16
14.	Unit Committees, meetings and other means provide for adequate communication.	35	44	13	7	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	55	18	13	5	7
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	11	13	29	22	24

TOTAL NO. OF SCIENTISTS RESPONDED = 55 (SSOs)

NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	17	22	6	39	11
2.	Lack of reward for performance retards achievement of research excellence.	11	33	11	17	28
3.	Scientists should put more effort into seeking what research be conducted.	56	22	17	--	6
4.	Internal Research Reviews encourage scientists to keep research content abreast.	67	22	--	11	--
5	Field Experimentation and Farm Operations are satisfactory/well organized.	28	61	11	--	--
6.	In general laboratories are adequate for research.	33	33	--	11	22
7.	The library resources and services are adequate for research.	22	39	11	17	11
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	6	28	6	28	33
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	11	6	17	67
10.	Operational funds for research are adequate and provided on time.	6	17	22	22	33
11.	Methods of allocating research resources to projects and individuals are satisfactory.	22	28	11	22	17
12.	My research is successfully integrated and coordinated with other institution scientists.	44	39	11	--	6
13.	Staff members at my level have an adequate voice in planning and conducting research.	56	11	6	17	11
14.	Unit Committees, meetings and other means provide for adequate communication.	44	33	17	--	6
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	44	33	17	6	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	22	33	6	11	28

TOTAL NO. OF SCIENTISTS RESPONDED = 18 (PSOs & CSOs)

NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	11	43	6	23	17
2.	Lack of reward for performance retards achievement of research excellence.	23	41	14	12	11
3.	Scientists should put more effort into seeking what research be conducted.	77	20	2	1	1
4.	Internal Research Reviews encourage scientists to keep research content abreast.	61	30	4	3	1
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	25	45	14	14	2
6.	In general laboratories are adequate for research.	32	42	11	11	4
7.	The library resources and services are adequate for research.	14	43	7	23	14
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	8	29	15	30	18
9.	Procurement procedures and practices ensure supplies and equipment on time.	4	15	12	23	47
10.	Operational funds for research are adequate and provided on time.	9	25	15	30	20
11.	Methods of allocating research resources to projects and individuals are satisfactory.	11	35	17	26	11
12.	My research is successfully integrated and coordinated with other institution scientists	34	42	14	8	3
13.	Staff members at my level have an adequate voice in planning and conducting research.	28	31	12	17	13
14.	Unit Committees, meetings and other means provide for adequate communication.	43	39	12	4	2
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	54	27	11	6	3
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	13	23	30	15	18

TOTAL NO. OF SCIENTISTS RESPONDED = 208 (SOs, SSOs, PSOs & CSOs)

PROGRAMME RICE NO. OF SCI. (4)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	25	50	--	--	25
2.	Lack of reward for performance retards achievement of research excellence.	--	75	--	25	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	75	25	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	25	75	--	--	--
6.	In general laboratories are adequate for research.	50	25	25	--	--
7.	The library resources and services are adequate for research.	25	50	25	--	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	50	50	--	--	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	50	25	--	25
10.	Operational funds for research are adequate and provided on time.	50	50	--	--	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	75	25	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	75	25	--	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	25	50	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	50	--	50	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	75	25	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	25	50	--	25	--

PROGRAMME MAIZE NO.OF SCI.(3)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	33	33	33	--
2.	Lack of reward for performance retards achievement of research excellence.	--	67	--	33	--
3.	Scientists should put more effort into seeking what research be conducted.	67	--	--	33	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	33	67	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	-	100	--	--	--
6.	In general laboratories are adequate for research.	-	100	--	--	--
7.	The library resources and services are adequate for research.	--	--	--	33	67
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	33	--	33	33
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	33	67
10.	Operational funds for research are adequate and provided on time.	--	33	--	67	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	67	33	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	33	--	67	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	100	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	67	33	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	--	67	33	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	67	--	33	--

PROGRAMME SOR.& MIL. NO.OF SCI.(2)*
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	-	50	50	--	--
2.	Lack of reward for performance retards achievement of research excellence.	50	50	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	50	50	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	50	50	--	--	--
6.	In general laboratories are adequate for research.	--	50	--	50	--
7.	The library resources and services are adequate for research.	--	100	--	--	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	50	50	--	--	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	50	50
10.	Operational funds for research are adequate and provided on time.	--	100	--	--	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	100	--	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	50	50	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	50	--	50	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	--	50	50	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	100	--	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	--	100	--	--

PROGRAMME SUGAR NO.OF SCI. (1)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	100	--	--	--
2.	Lack of reward for performance retards achievement of research excellence.	--	100	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	100	--	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	--	--	--	100
6.	In general laboratories are adequate for research.	--	100	--	--	--
7.	The library resources and services are adequate for research.	--	--	--	100	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	100	--	--	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	--	100
10.	Operational funds for research are adequate and provided on time.	--	--	--	100	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	100	--	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	100	--	--	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	100	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	--	100	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	100	--	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	100	--	--	--

PROGRAMME OILSEED NO.OF SCI. (6)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	50	33	--	17	--
2.	Lack of reward for performance retards achievement of research excellence.	83	17	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	33	67	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	17	50	--	33	--
6.	In general laboratories are adequate for research.	17	50	--	17	17
7.	The library resources and services are adequate for research.	--	33	--	67	--
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	--	50	--	33	17
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	17	--	83
10.	Operational funds for research are adequate and provided on time.	--	33	--	50	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	33	--	50	17
12.	My research is successfully integrated and coordinated with other institution scientists.	--	100	--	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	50	17	--	33
14.	Unit Committees, meetings and other means provide for adequate communication.	17	83	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	100	--	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	--	17	33	50

PROGRAMME PULSES NO.OF SCI. (7)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	71	--	29	--
2.	Lack of reward for performance retards achievement of research excellence.	--	43	43	14	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	57	29	14	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	14	29	29	29	--
6.	In general laboratories are adequate for research.	57	29	14	--	--
7.	The library resources and services are adequate for research.	29	43	14	14	--
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	14	43	29	14	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	43	57
10.	Operational funds for research are adequate and provided on time.	57	--	14	29	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	57	14	29	--
12.	My research is successfully integrated and coordinated with other institution scientists	14	71	--	14	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	29	43	29	--
14.	Unit Committees, meetings and other means provide for adequate communication.	43	29	14	--	14
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	71	29	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	43	14	14	29

PROGRAMME FRUIT NO.OF SCI.(4)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	75	25	--	--
2.	Lack of reward for performance retards achievement of research excellence.	50	50	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	25	75	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	75	--	25	--
6.	In general laboratories are adequate for research.	25	25	25	25	--
7.	The library resources and services are adequate for research.	--	75	25	--	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	25	50	—	25	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	25	--	50	25
10.	Operational funds for research are adequate and provided on time.	--	50	--	50	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	25	25	50	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	50	25	25	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	25	25	25	25	--
14.	Unit Committees, meetings and other means provide for adequate communication.	75	25	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	50	25	--	25	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	50	25	25	--

PROGRAMME VEGETABLE NO.OF SCI. (8)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	50	13	--	38
2.	Lack of reward for performance retards achievement of research excellence.	--	63	25	--	13
3.	Scientists should put more effort into seeking what research be conducted.	88	13	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	75	25	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	38	38	25	--	--
6.	In general laboratories are adequate for research.	38	50	13	--	--
7.	The library resources and services are adequate for research.	13	88	--	--	--
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	13	38	50	--	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	38	25	25	13
10.	Operational funds for research are adequate and provided on time.	--	63	13	13	13
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	88	13	--	--
12.	My research is successfully integrated and coordinated with other institution scientists	25	63	13	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	50	38	--	13	--
14.	Unit Committees, meetings and other means provide for adequate communication.	63	38	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	50	50	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	13	63	25	--	--

PROGRAMME PLANT VIR. NO.OF SCI.(4)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	25	--	--	--	75
2.	Lack of reward for performance retards achievement of research excellence.	25	50	--	--	25
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	50	50	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	75	25	--	--	--
6.	In general laboratories are adequate for research.	75	25	--	--	--
7.	The library resources and services are adequate for research.	--	50	--	25	25
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	100	--	--	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	25	25	50	--
10.	Operational funds for research are adequate and provided on time.	25	--	25	--	50
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	25	--	25	25
12.	My research is successfully integrated and coordinated with other institution scientists.	50	25	--	25	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	25	--	50	25
14.	Unit Committees, meetings and other means provide for adequate communication.	--	50	25	25	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	100	--	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	25	25	--	50	--

PROGRAMME T.CULTURE NO.OF SCI. (4)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	50	25	25	--
2.	Lack of reward for performance retards achievement of research excellence.	--	50	25	25	--
3.	Scientists should put more effort into seeking what research be conducted.	75	25	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	100	--	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	25	25	50	--
6.	In general laboratories are adequate for research.	25	25	--	25	25
7.	The library resources and services are adequate for research.	--	--	--	75	25
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	--	--	100	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	25	50	--	25
10.	Operational funds for research are adequate and provided on time.	--	--	25	25	50
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	--	25	75	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	75	25	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	25	--	25	--	50
14.	Unit Committees, meetings and other means provide for adequate communication.	25	25	25	25	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	25	25	--	25	25
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	25	25	--	50

PROGRAMME PGR NO. OF SCI. (4)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	100	--	--	--
2.	Lack of reward for performance retards achievement of research excellence.	--	75	25	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	25	75	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	25	--	75	--
6.	In general laboratories are adequate for research.	--	25	75	--	--
7.	The library resources and services are adequate for research.	--	75	--	25	--
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	--	--	--	75	25
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	50	50
10.	Operational funds for research are adequate and provided on time.	--	25	50	25	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	--	25	75	--
12.	My research is successfully integrated and coordinated with other institution scientists.	50	--	50	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	--	--	100	--
14.	Unit Committees, meetings and other means provide for adequate communication.	--	50	50	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	--	25	75	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	--	50	50	--

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PROGRAMME ENTOMOLOGY NO.OF SCI.(12)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	8	17	42	33
2.	Lack of reward for performance retards achievement of research excellence.	33	33	--	25	8
3.	Scientists should put more effort into seeking what research be conducted.	58	33	--	8	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	42	33	25	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	25	50	--	17	8
6.	In general laboratories are adequate for research.	58	42	--	--	--
7.	The library resources and services are adequate for research.	42	17	--	25	17
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	--	25	33	8	33
9.	Procurement procedures and practices ensure supplies and equipment on time.	17	8	--	25	50
10.	Operational funds for research are adequate and provided on time.	--	42	--	58	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	17	8	17	50	8
12.	My research is successfully integrated and coordinated with other institution scientists.	42	25	25	8	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	33	8	25	25	8
14.	Unit Committees, meetings and other means provide for adequate communication.	25	25	42	8	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	17	42	17	17	8
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	8	8	67	17	--

PROGRAMME : WEED NO. OF SCI. (6)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	67	--	17	17
2.	Lack of reward for performance retards achievement of research excellence.	17	17	17	33	17
3.	Scientists should put more effort into seeking what research be conducted.	83	17	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	17	33	--	50	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	17	50	17	17	--
6.	In general laboratories are adequate for research.	--	50	17	33	--
7.	The library resources and services are adequate for research.	--	83	--	17	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	17	17	33	33
9.	Procurement procedures and practices ensure supplies and equipment on time.	17	--	33	17	33
10.	Operational funds for research are adequate and provided on time.	--	33	50	17	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	33	--	50	17
12.	My research is successfully integrated and coordinated with other institution scientists.	33	--	17	50	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	17	50	--	--	33
14.	Unit Committees, meetings and other means provide for adequate communication.	33	67	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	50	17	17	--	17
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	--	50	17	33

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PROGRAMME FODDER NO. OF SCI. (4)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	100	--	--	--
2.	Lack of reward for performance retards achievement of research excellence.	75	25	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	75	25	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	75	--	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	75	--	25	--
6.	In general laboratories are adequate for research.	--	50	--	50	--
7.	The library resources and services are adequate for research.	--	50	--	50	--
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	--	25	--	50	25
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	25	75
10.	Operational funds for research are adequate and provided on time.	--	50	--	--	50
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	25	--	75	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	100	--	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	75	--	25	--
14.	Unit Committees, meetings and other means provide for adequate communication.	75	--	--	25	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	100	--	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	50	25	--	25	--

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PROGRAMME CYTOGENETICS NO. OF SCI.(3)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	100	--	--	--
2.	Lack of reward for performance retards achievement of research excellence.	--	67	33	--	--
3.	Scientists should put more effort into seeking what research be conducted.	67	33	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	67	33	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	--	67	33	--
6.	In general laboratories are adequate for research.	--	33	--	67	--
7.	The library resources and services are adequate for research.	--	--	--	33	67
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	--	33	--	67	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	33	--	--	67
10.	Operational funds for research are adequate and provided on time.	--	33	--	--	67
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	--	33	67	--
12.	My research is successfully integrated and coordinated with other institution scientists.	33	33	33	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	100	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	100	--	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	67	--	33	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	--	67	33	--

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PROGRAMME GR.STORAGE NO.OF SCI. (%)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	50	--	--	50	--
2.	Lack of reward for performance retards achievement of research excellence.	50	50	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	50	50	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	50	50	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	--	100	--	--
6.	In general laboratories are adequate for research.	50	--	--	--	50
7.	The library resources and services are adequate for research.	--	--	--	100	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	50	--	--	50
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	--	100
10.	Operational funds for research are adequate and provided on time.	--	50	--	50	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	100	--	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	100	--	--	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	--	--	--	100
14.	Unit Committees, meetings and other means provide for adequate communication.	50	50	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	100	--	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	--	50	--	50

PROGRAMME BARD NO.OF SCI. (11)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	9	9	64	18
2.	Lack of reward for performance retards achievement of research excellence.	9	36	9	18	27
3.	Scientists should put more effort into seeking what research be conducted.	82	18	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	73	9	--	--	18
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	73	18	--	9	--
6.	In general laboratories are adequate for research.	55	36	--	9	--
7.	The library resources and services are adequate for research.	55	--	--	27	18
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	36	9	9	36	9
9.	Procurement procedures and practices ensure supplies and equipment on time.	45	--	27	9	18
10.	Operational funds for research are adequate and provided on time.	18	64	--	18	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	45	36	9	9	--
12.	My research is successfully integrated and coordinated with other institution scientists.	64	18	18	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	55	36	--	--	9
14.	Unit Committees, meetings and other means provide for adequate communication.	64	18	9	--	9
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	82	--	9	--	9
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	27	18	36	9	9

PROGRAMME CDRI NO. OF SCI. (12)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	8	50	17	25	--
2.	Lack of reward for performance retards achievement of research excellence.	50	33	--	8	8
3.	Scientists should put more effort into seeking what research be conducted.	67	25	--	--	8
4.	Internal Research Reviews encourage scientists to keep research content abreast.	75	8	17	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	25	50	8	8	8
6.	In general laboratories are adequate for research.	33	42	--	16	8
7.	The library resources and services are adequate for research.	--	42	33	8	16
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	8	42	25	--	25
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	16	16	25	42
10.	Operational funds for research are adequate and provided on time.	--	42	16	25	16
11.	Methods of allocating research resources to projects and individuals are satisfactory.	8	25	16	8	42
12.	My research is successfully integrated and coordinated with other institution scientists.	75	25	--	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	8	33	--	25	33
14.	Unit Committees, meetings and other means provide for adequate communication.	33	42	--	8	16
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	42	42	--	--	16
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	25	--	16	58

PROGRAMME R&FQ NO.OF SCI. (8)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	13	--	--	38	50
2.	Lack of reward for performance retards achievement of research excellence.	25	63	13	--	--
3.	Scientists should put more effort into seeking what research be conducted.	88	13	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	63	38	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	50	50	--	--	--
6.	In general laboratories are adequate for research.	75	25	--	--	--
7.	The library resources and services are adequate for research.	13	38	13	--	38
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	13	38	25	13	13
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	38	--	13	50
10.	Operational funds for research are adequate and provided on time.	63	13	25	--	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	50	25	25	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	50	38	13	--	--
13.	Staff members at my level have an adequate voice in planaing and conducting research.	38	13	13	13	25
14.	Unit Committees, meetings and other means provide for adequate communication.	50	50	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	63	25	13	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	13	25	13	50

PROGRAMME WHEAT NO. OF SCI. (4)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	75	25	--	--	--
2.	Lack of reward for performance retards achievement of research excellence.	100	--	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	25	75	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	25	75	--	--	--
6.	In general laboratories are adequate for research.	25	50	25	--	--
7.	The library resources and services are adequate for research.	--	75	--	25	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	25	75	--	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	25	--	25	50
10.	Operational funds for research are adequate and provided on time.	--	--	25	--	75
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	--	--	25	75
12.	My research is successfully integrated and coordinated with other institution scientists.	75	--	--	--	25
13.	Staff members at my level have an adequate voice in planning and conducting research.	50	50	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	25	75	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	75	--	--	25	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	25	--	--	50	25

PROGRAMME LRS NO.OF SCI.(20)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	5	40	5	30	20
2.	Lack of reward for performance retards achievement of research excellence.	10	25	35	20	10
3.	Scientists should put more effort into seeking what research be conducted.	60	30	10	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	60	20	10	10	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	35	35	30	--	--
6.	In general laboratories are adequate for research.	40	50	10	--	--
7.	The library resources and services are adequate for research.	25	50	--	15	10
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	10	25	10	35	20
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	10	--	35	55
10.	Operational funds for research are adequate and provided on time.	5	--	30	40	25
11.	Methods of allocating research resources to projects and individuals are satisfactory.	25	30	10	15	20
12.	My research is successfully integrated and coordinated with other institution scientists.	50	30	10	5	5
13.	Staff members at my level have an adequate voice in planning and conducting research.	50	30	10	--	10
14.	Unit Committees, meetings and other means provide for adequate communication.	70	25	5	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	85	10	--	5	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	15	20	45	--	20

PROGRAMME R & W NO. OF SCI. (10)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	10	40	10	--	40
2.	Lack of reward for performance retards achievement of research excellence.	20	30	10	20	20
3.	Scientists should put more effort into seeking what research be conducted.	50	20	10	--	20
4.	Internal Research Reviews encourage scientists to keep research content abreast.	60	40	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	30	50	10	10	--
6.	In general laboratories are adequate for research.	40	60	--	--	--
7.	The library resources and services are adequate for research.	10	30	20	20	20
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	--	20	20	40	20
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	20	20	10	50
10.	Operational funds for research are adequate and provided on time.	--	10	40	20	30
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	30	40	20	10
12.	My research is successfully integrated and coordinated with other institution scientists.	10	60	10	10	10
13.	Staff members at my level have an adequate voice in planning and conducting research.	40	20	--	30	10
14.	Unit Committees, meetings and other means provide for adequate communication.	40	50	10	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	50	20	30	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	10	20	10	--	60

PROGRAMME COMP.& STAT.NO.OF SCI.(3)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	--	67	--	33
2.	Lack of reward for performance retards achievement of research excellence.	--	--	33	67	--
3.	Scientists should put more effort into seeking what research be conducted.	67	33	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	67	--	33	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	33	67	--	--	--
6.	In general laboratories are adequate for research.	100	--	--	--	--
7.	The library resources and services are adequate for research.	--	33	33	33	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	--	--	67	33
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	33	33	33
10.	Operational funds for research are adequate and provided on time.	--	33	33	33	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	67	--	33	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	67	--	--	33
13.	Staff members at my level have an adequate voice in planning and conducting research.	33	--	33	33	--
14.	Unit Committees, meetings and other means provide for adequate communication.	33	33	--	33	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	--	67	--	33	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	33	--	--	67	--

PROGRAMME LEM NO.OF SCI. (1)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	--	--	--	100
2.	Lack of reward for performance retards achievement of research excellence.	--	100	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	100	--	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	--	100	--	--
6.	In general laboratories are adequate for research.	100	--	--	--	--
7.	The library resources and services are adequate for research.	--	--	100	--	--
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	--	--	--	--	100
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	--	100
10.	Operational funds for research are adequate and provided on time.	--	--	--	100	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	--	--	100	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	--	100	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	--	--	100	--
14.	Unit Committees, meetings and other means provide for adequate communication.	100	--	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	--	100	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	--	100	--	--

PROGRAMME AERU NO.OF SCI. (4)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	--	--	75	25
2.	Lack of reward for performance retards achievement of research excellence.	--	75	25	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	100	--	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	25	--	75	--	--
6.	In general laboratories are adequate for research.	--	25	75	--	--
7.	The library resources and services are adequate for research.	--	75	--	25	--
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	--	25	25	50	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	25	75
10.	Operational funds for research are adequate and provided on time.	25	25	--	--	50
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	25	50	25	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	50	25	25	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	25	--	--	25	50
14.	Unit Committees, meetings and other means provide for adequate communication.	--	100	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	25	50	25	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	25	--	25	25	25

PROGRAMME SIU NO.OF SCI. (4)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	--	--	--	100
2.	Lack of reward for performance retards achievement of research excellence.	--	100	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	100	--	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	100	--	--	--	--
6.	In general Laboratories are adequate for research.	100	--	--	--	--
7.	The library resources and services are adequate for research.	--	100	--	--	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	100	--	--	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	100	--	--	--
10.	Operational funds for research are adequate and provided on time.	--	--	--	100	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	100	--	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	100	--	--	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	100	--	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	100	--	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	100	--	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	100	--	--	--	--

PROGRAMME TRG. INSTT. NO.OF SCI. (4)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	25	50	--	--	25
2.	Lack of reward for performance retards achievement of research excellence.	25	50	--	--	25
3.	Scientists should put more effort into seeking what research be conducted.	50	50	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	75	--	25	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	50	25	25	--	--
6.	In general laboratories are adequate for research.	25	--	50	--	25
7.	The library resources and services are adequate for research.	--	--	25	75	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	25	50	--	25
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	25	25	50
10.	Operational funds for research are adequate and provided on time.	25	--	50	25	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	25	25	25	25	--
12.	My research is successfully integrated and coordinated with other institution scientists.	50	25	25	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	25	75	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	75	--	25	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	25	--	25	50	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	25	--	50	25	--

PROGRAMME FMI NO.OF SCI. (10)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	10	80	10	--	--
2.	Lack of reward for performance retards achievement of research excellence.	60	40	--	--	--
3.	Scientists should put more effort into seeking what research be conducted.	10	90	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	50	40	--	10	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	20	40	30	10	--
6.	In general laboratories are adequate for research.	30	40	--	30	--
7.	The library resources and services are adequate for research.	10	70	10	--	10
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	10	30	50	10
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	10	50	30	10
10.	Operational funds for research are adequate and provided on time.	20	20	40	--	20
11.	Methods of allocating research resources to projects and individuals are satisfactory.	20	20	10	50	--
12.	My research is successfully integrated and coordinated with other institution scientists.	40	30	10	10	10
13.	Staff members at my level have an adequate voice in planning and conducting research.	30	30	10	10	20
14.	Unit Committees, meetings and other means provide for adequate communication.	70	10	10	--	10
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	40	30	10	20	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	10	10	20	30	30

PROGRAMME WATER RES. NO.OF SCI.(9)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	78	11	11	--
2.	Lack of reward for performance retards achievement of research excellence.	11	56	22	--	11
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	89	11	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	67	22	11	--
6.	In general laboratories are adequate for research.	--	22	44	33	--
7.	The library resources and services are adequate for research.	--	11	--	56	33
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	22	11	--	67
9.	Procurement procedures and practices ensure supplies and equipment on time.	11	--	11	33	44
10.	Operational funds for research are adequate and provided on time.	--	--	11	44	44
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	44	33	--	22
12.	My research is successfully integrated and coordinated with other institution scientists.	--	67	22	11	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	--	55	33	11
14.	Unit Committees, meetings and other means provide for adequate communication.	--	89	11	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	11	56	33	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	33	67	--	--

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PROGRAMME SERICULTURE NO.OF SCI. (1)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	100	--	--	--
2.	Lack of reward for performance retards achievement of research excellence.	--	--	100	--	--
3.	Scientists should put more effort into seeking what research be conducted.	100	--	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	100	--	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	--	100	--	--
6.	In general laboratories are adequate for research.	--	--	--	100	--
7.	The library resources and services are adequate for research.	--	--	--	100	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	--	--	100	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	100	--
10.	Operational funds for research are adequate and provided on time.	--	--	--	100	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	--	100	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	--	100	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	--	100	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	--	100	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	--	100	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	100	--	--	--

PROGRAMME HONEYBEE NO.OF SCI. (4)
NARC MASTER RESEARCH PLAN SECRETARIAT
ANALYSIS OF QUESTIONNAIRE
(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	--	--	--	100	--
2.	Lack of reward for performance retards achievement of research excellence.	--	--	--	--	100
3.	Scientists should put more effort into seeking what research be conducted.	--	100	--	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	--	100	--	--	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	--	100	--	--	--
6.	In general laboratories are adequate for research.	--	100	--	--	--
7.	The library resources and services are adequate for research.	--	100	--	--	--
8.	Satisfactory system exists for ordering/ obtaining additions to the lab & lib. for my research.	--	--	--	100	--
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	--	--	--	100
10.	Operational funds for research are adequate and provided on time.	--	100	--	--	--
11.	Methods of allocating research resources to projects and individuals are satisfactory.	25	75	--	--	--
12.	My research is successfully integrated and coordinated with other institution scientists.	--	100	--	--	--
13.	Staff members at my level have an adequate voice in planning and conducting research.	75	25	--	--	--
14.	Unit Committees, meetings and other means provide for adequate communication.	75	25	--	--	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	75	25	--	--	--
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	--	75	25	--	--

PROGRAMME AS1 NO. OF SCI. (29)

NARC MASTER RESEARCH PLAN SECRETARIAT

ANALYSIS OF QUESTIONNAIRE

(Q. 1 - 16)

Q.No.	Description	A	B	C	D	E
1.	Inadequate facilities preclude quality research.	28	45	--	28	--
2.	Lack of reward for performance retards achievement of research excellence.	14	38	21	10	17
3.	Scientists should put more effort into seeking what research be conducted.	66	31	3	--	--
4.	Internal Research Reviews encourage scientists to keep research content abreast.	66	31	--	3	--
5.	Field Experimentation and Farm Operations are satisfactory/well organized.	7	48	10	31	3
6.	In general laboratories are adequate for research.	10	55	14	10	10
7.	The library resources and services are adequate for research.	17	45	--	17	21
8.	Satisfactory system exists for ordering/obtaining additions to the lab & lib. for my research.	7	24	3	48	17
9.	Procurement procedures and practices ensure supplies and equipment on time.	--	17	3	17	62
10.	Operational funds for research are adequate and provided on time.	--	14	7	41	38
11.	Methods of allocating research resources to projects and individuals are satisfactory.	--	28	21	34	14
12.	My research is successfully integrated and coordinated with other institution scientists.	17	55	17	7	3
13.	Staff members at my level have an adequate voice in planning and conducting research.	21	41	14	21	3
14.	Unit Committees, meetings and other means provide for adequate communication.	28	45	21	7	--
15.	Opportunity for advancement at NARC is an incentive for me to do excellent work.	45	38	10	3	3
16.	A satisfactory mechanism for selecting for special awards and recognitions exists.	17	31	38	10	3

HOW ARE RESEARCH PROGRAMS LINKED AND COORDINATED?

1. TECHNICAL WORKING GROUP/RESEARCH COMMITTEE. - 65%

2. MEETINGS, SEMINARS, RESEARCH REPORTS AND SHARED FACILITIES. - 27%

3. COORDINATED PROJECTS. - 24%

4. POOR OR NOT IDEAL COORDINATION - 22%

HOW CAN THIS INTEGRATION AND COORDINATION BE IMPROVED?

1. SHARING RESOURCES WITH SEVERAL EXPERIMENTS IN COLLABORATION WITH OTHER PROGRAMS. ADMINISTRATIVE AND MANAGEMENT TRAINING TO PROGRAM LEADERS WILL HELP. - 43%

2. MORE EXCHANGE OF INFORMATION THROUGH TWG, RESEARCH COMMITTEE AND CROP ADVISORY COMMITTEE/IMPROVED COMMUNICATION BETWEEN LABS. AND FIELD. - 41%

3. STRENGTHENING PLANNING RESEARCH & MONITORING CELL (EG. WITH COMPUTER TERMINALS). - 11%

4. AWARDS TO SCIENTISTS AND STAFF EXCHANGE. - 5%

HOW CAN LINKAGE WITH INTERNATIONAL INSTITUTIONS BE STRENGTHENED.

1. EXCHANGE OF VISITING SCIENTISTS, SEMINARS, WORKSHOPS ETC. SIMPLIFY PROCEDURES FOR RESEARCH EXPERIENCE ABROAD. - 95%

2. EXCHANGE AND CIRCULATION OF SCIENTIFIC INFORMATIONS (REPORTS, NEWSLETTERS ETC.) LITERATURE, GERMPLASM AND MEMBERSHIP OF INTERNATIONAL SOCIETIES. - 49%

3. JOINT OR COLLABORATIVE RESEARCH PROGRAMS WITH INTERNATIONAL INSTITUTIONS. - 19%

4. ACTIVE SCIENTISTS SHOULD BE GIVEN PREFERENCE OVER DIRECTORS FOR PARTICIPATION IN INTERNATIONAL SYMPOSIA ETC. - 5%

WHAT PROCEDURE EXISTS TO DETERMINE WHETHER RESEARCH IS RELEVANT TO FARMER'S NEEDS?

1. NARC TECHNICAL WORKING GROUP, RESEARCH COMMITTEE AND PARC (DDWG, CDWP). - 54%

2. FARMER FEEDBACK AND EXTENSION/TECHNOLOGY TRANSFER AND LITERATURE. - 19%

3. NO PROCEDURE EXISTS TO DETERMINE RESEARCH FOR FARMER NEEDS. NOT APPLICABLE. - 19%

4. NONE OR IRRELEVANT RESPONSE - 14%

WHAT PROCEDURE EXISTS TO DETERMINE WHETHER RESEARCH RESULTS ARE ADAPTABLE TO FARM?

1. THROUGH COMMODITY ON-FARM RESEARCH, EXTENSION WING AND FSR. - 49%

2. REVIEW BY TWG, SEMINARS, ANNUAL MEETINGS. - 8%

3. DEGREE OF SOCIO-ECONOMIC COMPATIBILITY - 8%

4. NO CLEAR PROCEDURE EXISTS. NONE OR IRRELEVANT RESPONSE. NO APPLICABLE. - 35%

HOW CAN A FARMING SYSTEM RESEARCH THRUST AFFECT YOUR PROJECT PERFORMANCE?

1. INFORMATION FROM FSR USEFUL TO GUIDE RESEARCH FOCUS AND FARMERS VALIDATE RESEARCH INSTITUTE RESULTS. - 59%

2. FSR SHOULD PROVIDE FACILITIES (FUNDS, EQUIPMENT, STAFF). - 5%

3. FSR RESULTS SHOULD BE TRANSLATED THROUGH WORKSHOPS/COURSES. - 3%

4. NOT APPLICABLE. NONE OR IRRELEVANT RESPONSE. - 32%

LIST THE MOST SIGNIFICANT RESEARCH PROJECTS NOW UNDERWAY WHICH DEAL WITH THE FUTURE OR COMING NEEDS OF THE PROVINCES:

Note: The following are statements which represent abstracts of Questionnaire responses.

(1) RICE - No Response

(2) MAIE

(a) Development/screening of germplasm for cold/drought tolerance.

(b) Development of early maturity maize population resistant to stalk rot and rust diseases.

(3) SORGHUM & MILLET

(a) Breeding of dual purpose sorghum varieties by crosses between selected local and exotic parents.

(b) Development of hybrids of sorghum - screening of A/B and R Lines.

(c) Development of desirable (bristled) millet composites.

(4) OILSEED - Research on non-traditional oilseed crops such as sunflower, soybean & safflower.

(5) PULSES

(a) Breeding/screening for disease resistance and integrated control of important pests.

(6) FRUITS

(a) Evaluation of world famous cultivars of deciduous fruits and citrus which will be later introduced in NWFP & Baluchistan and Punjab & Sind respectively.

(7) PLANT VIROLOGY

(a) Cooperative program for research, productivity improvement and marketing of potatoes.

(b) Pest management programs in important crops.

(c) Identification of viruses and development of quick diagnostic techniques.

(d) Production and distribution of disease free seeds.

(e) On-farm research programs.

(8) TISSUE CULTURE

(a) The rational coordinated programs at NARC and training manpower.

9. PLANT GENETIC RESOURCES

(a) Collection of sorghum, millet, maize, fodder, forage, wild cicer and lentil etc.

(b) Conservation and evaluation of cereals, food legumes and pulses.

(c) Documentation of plant genetic resources information.

(d) Distribution of crop germplasm.

10. PLANT INTRODUCTION CENTRE

(a) Distribution of exotic germplasm, introduction of exotic plants with high economic value suitable for different ecologies.

11. ENTOMOLOGY

(a) Help the provincial scientists in developing varieties resistant to pests.

12. WEED

(a) Herbicide evaluation and methods of application.

(b) Cultural methods of weed control.

(c) Allelopathy, biology and ecology of weeds.

13. FODDER

(a) Germplasm collection and evaluation for evolution of new nutritive and leguminous fodder crops.

(b) To select/identify fodder legume varieties for mountainous areas.

(c) Fitting of different crop varieties in the system.

14. CROP MAXIMIZATION PROGRAM

(a) Considering crop maximization program as a pilot project to establish/demonstrate mechanism to enhance productivity levels of major cereal crops, this project very well deals with further needs of the provinces in improving crop yield through farm mechanization.

15. CYTOGENETICS

(a) Tea project for NWFP.

(b) Grasspea for Sind, Mung and Mash for Sind & Punjab.

(c) *Brassica* for Punjab.

(d) Wheat for all the four provinces.

16. GRAIN STORAGE – No Comments.

(17) BARD

(a) Deep tillage and appropriate mechanization; design of machinery, evaluating and development of new varieties and diffusio of research findings.

(18) CROP DISEASES RESEARCH INSTITUTE

(a) Whatever research is being carried out takes care of the existing and future needs of the provinces.

(19) NUTRITION & FOOD QUALITY

(a) Effect of production environment on the quality of food grains (cereals & legumes).

(b) Effect of different packaging materials on the quality of wheat flour.

(c) Nutritional quality and consumer acceptance of food crops.

(d) Improving the quality of bread and to produce more bread from less wheat.

(e) Development of new food products.

(20) LAND RESOURCES

(a) Soil K, S, micronutrient and soil mineralogy research, soil physics and material dynamics in soil. Soil fertility evaluation and improvement

(b) Research on the chemistry/fertility of flooded lowland rice.

(c) Fertility management under rice based cropping system.

(21) RANGE & WATERSHED

(a) Forage & pasture, agro-forestry, range management, watershed management, agro-ecological zones of Pakistan and remote sensing.

(22) WATER RESOURCES

(a) High efficiency irrigation systems (sprinkler & trickle).

(23) SERICULTURE

(a) A coordinated sericulture program at NARC.

(24) HONEYBEE RESEARCH PROGRAM

(a) Work on bee keeping is going on a small scale in the provinces. Research work needs to be strengthened to deal with the future and coming needs of the provinces.

(25) ANIMAL SCIENCES INSTITUTE

(a) Projects in the field of animal nutrition, breeding, reproductive physiology, health, management etc.

(b) A national coordinated research project on meat involving various coordinated units in provinces is submitted to the Planning Division.

(c) Development/improvement of effective vaccine of long duration against Haemmorrhagic septicaemia.

(d) Combined vaccination program against Haemmorrhagic septicaemia and foot & mouth disease.

(26) ANIMAL NUTRITION

(a) Upgrading the nutritional value of crop residues and agro-industrial wastes and by-products. Use of animal wastes in livestock feeding. Development of appropriate feeding and management systems, unconventional feedstuffs. Complete formula feeds/least cost rations.

(27) DAIRY CATTLE AND CROSS BREEDING

(a) Production of progeny tested buffaloe bulls.

(b) Cross-breeding of local cattle for more milk production.

(c) Coordinated research project on buffaloe reproduction.

(d) Problems of pubertal development in Nili-Ravi buffaloe bulls.

(28) SHEEP & WOOL

(a) Studies on: i) introduction of Rawbovillet genes to Kaghani breed of sheep.

ii) Follicle population of various breeds of sheep.

iii) Use of urea molasses blocks as supplement of conventional rations and its effects on live weight and wool production of sheep.

LIST AREAS IN WHICH RESEARCH GAPS EXIST?

Note: The following are statements which represent abstracts of Questionnaire responses.

(1) RICE

(a) Pest Management
(b) Nutrient Management
(c) Direct Seeding

(2) MAIZE - No Response

(3) SORGHUM & MILLET

(a) Breeding for pests & disease resistance.

(b) Determination of suitable cultural practices under farmers conditions.

(4) OILSEED

(a) Research on breeding, agronomy, disease and economic aspects of oilseed crops.

(5) PULSES

(a) Varietal improvement.

(b) Disease/insect resistant varieties.

(c) Improved production technology.

(6) FRUITS

(a) Pre- and post-harvest physiology of fruits.

(b) Use of growth regulators in fruit crops.

(c) Breeding, insect and pest losses in fruit crops.

(7) PLANT VIROLOGY

(a) On-farm research programs to exploit yield potentials.

(b) Genotype-environment interactions.

(c) Control of systemic disease.

(d) Marketing research.

(e) Post-harvest technology.

(f) Assessment of losses due to important pests and diseases.

(g) Environmental pollution.

(8) TISSUE CULTURE

(a) There should be an equilibrium between basic and applied research.

(9) PLANT GENETIC RESOURCES

(a) Proper storage facility for long and medium genebank.

(b) A computer for documentation of GRI.

(10) PLANT INTRODUCTION CENTRE

(a) Proper post entry quarantine and centralized documentation of imported plant material and their preliminary performance data record.

(11) ENTOMOLOGY

(a) Computer modelling of major pests in agroecosystem.

(b) Use of pheramones in monitoring insect populations.

(c) Detection of insect biotypes resistant to insecticides.

(d) Virul-vector relationship.

(12) WEED

(a) Allelopathy (b) Biology and ecology of weeds (c) Identification of weeds (d) Ecological distribution of weeds.

(13) FODDER

(a) Testing varieties in the farming systems.

(b) Feeding trials of improved varieties.

(c) Breeding varieties on mountainous area and for drought tolerance, water logging and salt tolerance.

(14) CROP MAXIMIZATION PROGRAM

A- 1. Dual purpose variety of maize for NWFP. Separate varieties of maize for fodder and grain production.

2. Use of hybrid potential in maize at least for progressive growers.

3. Breeding for stress tolerant, insect, disease resistant varieties.

4. Mechanical and chemical weed control.

5. Mechanism of marketing of maize grain.

B- MECHANIZATION

1. Use of appropriate tillage implements for various operations.

2. Manufacturing of improved implements in the country which fit into existing energy of our tractors.

3. Appropriate machinery for sowing, interculture and harvesting/threshing of various crops.

(15) CYTOGENETICS

(a) Haploid breeding, (b) Protoplast fusion, (c) Gene manipulation, (d) Extra-nuclear genetics.

(16) GRAIN STORAGE

(a) Post-harvest research of food grains.

(17) BARANI AGRICULTURAL RESEARCH & DEVELOPMENT

(a) Soil, water plant relationship remains to be an area for further investigation.

(18) CROP DISEASES RESEARCH INSTITUTE

(a) There are always gaps in all areas, it is the job who feedbacks to bring such gaps to the notice of researchers.

(19) NUTRITION AND FOOD QUALITY

(a) Effect of production environment on the nutritional quality of cereals, pulses, oilseeds and vegetables.

(b) Development of new food products.

(c) Quality of bread and to have more bread from less wheat.

(d) Digestibility of food legumes.

(e) Antinutritional factors in cereals and legumes.

(f) Quality of diet consumed in different agro-ecological zones of the country.

(g) Effect of storage on the quality of food grains.

(h) Pesticide residues in cooked food products and the possible interaction of these residues with different spices under local cooking conditions.

(i) Impact of agricultural and food supply policies on the nutritional status of the local population.

(j) Trace element content of foods and diets.

(20) LAND RESOURCES

(a) Soil K, S, micronutrient, mineralogy research. Soil physics and nutrient dynamics in soil.

(b) Soil fertility evaluation and improvement.

(c) No systematic research on the chemistry/fertility of flooded rice soils and rice-based cropping system is being done in the country except that done by PSO (Rice soils) and young scientists at Dakri & K.S.K. Research on this aspect needs to be strengthened by deputing more staff by PARC.

(21) RANGE AND WATERSHED

(a) Remote sensing Unit, (b) Ecology program.

(22) WATER RESOURCES

(a) Development of high technologies in irrigation systems.

(23) SERICULTURE

(a) Development of pure lines of silkworm and better yielding mulberry varieties. Non-mulberry silkworm and their flora.

(24) HONEYBEE RESEARCH PROGRAM

(a) Honeybee pollination of crops, pollen and nectar potential of important honey plants, nutrition of honeybees and control of honeybee mites.

(25) ANIMAL SCIENCES INSTITUTE

A- 1. Research gaps exist in goat and sheep production, housing and management of livestock, and also in various aspects of breeding, nutrition, health and reproduction.

B- MEAT

1. Lack of superior beef and mutton breeds in the country.

2. Lack of modern slaughter houses.

3. Lack of meat processing and preservation facilities.

4. Lack of livestock and meat marketing facilities.

C- ANIMAL HEALTH

1. There is a great need to adopt new technologies for diagnosis of diseases.

D- ANIMAL NUTRITION

1. Establish nutrient requirement of various classes of livestock including dinught animals under diverse ecological farming systems. Studies on the interaction between environment and nutrition.

E- DAIRY CATTLE & CROSS BREEDING

1. Improvement of large/small ruminants through breeding.

2. Problems of reproduction both in buffaloes and cattle.

3. Feeds and feeding.

4. Marketing of animals and their by-products.

F- SHEEP & WOOL

1. Productive and reproductive traits of sheep have not been studied on scientific lines.

(26) TRAINING INSTITUTE

(a) Agricultural extension.

(27) FARM MACHINERY INSTITUTE

(a) Identification of goals and responsibilities.

(28) COMPUTER & STATISTICS

(a) Multivariate analysis, (b) Field Plot Techniques, (c) Plot sampling procedures.

(29) PUBLICATION & SCIENTIFIC INFORMATION

(a) Improved computer technologies for information acquisition, storage, retrieval and dissemination.

(30) AGRICULTURAL ECONOMICS RESEARCH UNIT

(a) Optimal soil and water management techniques under rainfed conditions, particularly.

(b) Policy studies regarding insurance policy, subsidy and support pricing issues as well as other macro economic problems, farm managers, planners and policy makers.

LIST THE OUTSTANDING CONTRIBUTION OF BASIC RESEARCH TO THE SOLUTION OF FARM PROBLEMS?

Note: The following are statements which represent abstracts of Questionnaire responses.

(1) RICE - It is always basic research that helps to solve problems.

(2) MAIZE

(a) The use of herbicides for controlling weeds.

(b) Development of high yielding maize varieties.

(c) Use of optimal fertilizer dose for better net returns.

(3) SORGHUM & MILLET - No Response

(4) OILSEED

(a) Development of production technology for oilseed crops in different ecological zones.

(5) PULSES

(a) Mostly deal with applied research.

(6) FRUITS

(a) All applied research is based on basic research.

(7) PLANT VIROLOGY

(a) Screening, selection and acclimatisation of germplasm, hybrid seed production.

(b) Identification diseases, mode of infection, disease forecasting and development of spray schedules.

(c) Water requirement of crops.

(d) Rapid multiplication techniques.

(e) New genetic approaches.

(8) TISSUE CULTURE - Virus free seed potato produced by tissue culture has been successfully tested in a farmers field in the Northern Hilly areas of Pakistan, for pre-basic and basic seed production. This seed would be multiplied next summer for certified seed. This is the first step towards dispensing with the import of seed potato each year which could meet only 3% of our seed requirement. This is an example of collaboration between scientists in the lab. and farmers in the field. Once streamlined, the farmers would be the end users and would get clean seed at comparatively cheaper rates.

(9) PLANT GENETIC RESOURCES - No Response.

(10) PLANT INTRODUCTION CENTRE - No Response.

(11) ENTOMOLOGY - No Response.

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(12) WEED - Methods of herbicide application and weed management through light management.

(13) FODDER - The proximate analysis of the improved fodder crop varieties for determining the fodder quality and nutrition value of varieties.

(14) CROP MAXIMIZATION PROGRAM

(a) Testing and selection of germplasm, hybridization - hybrid seed.

(b) Identification of life cycle of insects and diseases.

(c) Chemical weed control.

(15) CYTOGENETICS - Colchicine could induce meiotic mutation and used for producing seed sterlity in vegetatively propagated economic plants such as tea.

(16) GRAIN STORAGE

Genetics which leads to breeding of new varieties.

(17) BARANI AGRICULTURAL RESEARCH & DEVELOPMENT - No basic research is conducted by BARD.

(18) CROP DISEASES RESEARCH INSTITUTE - There can't be any applied research and therefore no solution to problems unless basic research is carried out.

(19) NUTRITION AND FOOD QUALITY

(a) We have made the farmer and the plant scientists concious about the quality of food crops.

(b) We have improved the quality of the diet by different processing techniques.

(c) We have improved the quality of wheat protein by supplementation with potato protein.

(20) LAND RESOURCES

(a) Use of labelled materials to trace in pathway of added plant nutrients.

(b) Process of nutrient uptake by plant roots.

(c) Analytical techniques for analyzing soil and plant for macro and micro nutrients.

(d) Chemistry of nutrients in soils.

(e) Research on N^{15} labelled materials under flooded soils will help in understanding various mechanisms of N losses from paddy fields, which will help in improving fertilizer use efficiency.

(21) RANGE & WATERSHED - No basic research has been conducted by us.

(22) WATER RESOURCES - Irrigation efficiencies, uniformity coefficient, crop coefficient curves etc.

(23) SERICULTURE - Studies on silkworm rearing techniques, diseases and flora.

(24) HONEYBEE RESEARCH PROGRAM

Studies on honeybee flora, pests and diseases and their control and management of the honeybee colonies.

(25) ANIMAL SCIENCES INSTITUTE

A- 1. Leads the way to applied research for solving practical problems.

2. Basic studies on meat production capabilities of farm animals will help in the identification of superior meat producing breeds/strains and will increase the income of farmers producing livestock.

3. Research on subclinical mastitis and on calf mortality have helped progressive farmers.

B- ANIMAL NUTRITION

1. Technologies for the treatment of crop residues/cellulosic wastes.

2. Preservation methods of feed resources.

3. Use of poultry litter/animal wastes.

C- DAIRY CATTLE & CROSS BREEDING

1. Research on the biology of sperms, its preservation etc. to make strides in the improvement of livestock.

2. Basic technology in the improvement of feeds.

D- SHEEP & WOOL

1. Utilization of urea molasses blocks as cheap source of energy and protein for sheep production in Northern areas in winter, will not only reduce/stop mortality but will also maintain the health of sheep.

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(26) TRAINING INSTITUTE - Relates to Research Programme.

(27) FARM MACHINERY INSTITUTE - No Comments.

(28) COMPUTER & STATISTICS

Basic research is a pre requisite but costly and time consuming. However, it has not significant impact (direct) on farm problems.

(29) PUBLICATION AND SCIENTIFIC INFORMATION - Not Applicable.

(30) AGRICULTURAL ECONOMICS RESEARCH UNIT

(a) Designing of component technology for various types of farmers in different recommendation domains.

(b) Cooperative farming movement and its success story for pooling of input and output resources with special reference to small farmers development.

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LIST THE BASIC RESEARCH AREAS/TOPICS YOU CONSIDER ESSENTIAL TO SUPPORT APPLIED RESEARCH AND SOLUTION OF FARM PROBLEMS.

Note: The following are statements which represent abstracts of Questionnaire responses.

(1) RICE - Physiological basis of crop growth. Genetic manipulation for resistant to stress.

(2) MAIZE

(a) Development of early maturing high yielding maize hybrids.

(b) Identification/development of germplasm tolerant to cold/drought.

(3) SORGHUM & MILLET - Genetics, Cytogenetics and Physiology.

(4) OILSEED - Breeding and agronomic practices and effective control of diseases alongwith economic aspects of non-traditional crops.

(5) PULSES

(a) Studies on survival of chickpea blight.

(b) Studies on epidemiology of plant diseases and weed control aspects.

(6) FRUIT

(a) Breeding of new cultivars.

(b) Protection of crops.

(c) Post harvest physiology.

(d) Chemical use as growth regulator.

(7) PLANT VIROLOGY

(a) Production of viral antisera and Elisa kits.

(b) Production of virus-free seed

(c) Population dynamics of aphids and vectors

(d) Spray schedules.

(e) Nuclear polyhedral viruses (NPV)

(f) Biological control of insects.

(g) Detection of mycoplasmas and virus-like diseases.

(h) Control of diseases.

(8) TISSUE CULTURE - Plant tissue culture, plant pathology, virology, microbiology, biochemistry, physiology, ecology, entomology, pest management etc.

(9) PLANT GENETIC RESOURCES - Not Applicable.

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(10) PLANT INTRODUCTION CENTRE

Necessary studies on under-exploited plants for their use in future as a source of food, feed, fat, protein, fiber and medicines.

(11) ENTOMOLOGY

(a) Computer modelling of major pests in agroecosystem.

(b) Use of pheramones in monitoring insect population.

(c) Detection of insect biotypes resistant to insecticides.

(d) Virus-vector relationship.

(12) WEED

Identification of weeds, ecological distribution of weeds, Biology and ecology of weeds, herbicide physiology/herbicides residue.

(13) FODDER

(a) Proximate analysis of different improved fodder varieties.

(b) Soil analysis for determining the nutritional status of the soils.

(c) Digestibility trials with livestock.

(14) CROP MAXIMIZATION PROGRAM

(a) Residual effect of insecticides and weedicides.

(b) Selection of varieties for environmental stresses - drought, cold, saline conditions etc.

(c) Selection and testing of germplasm.

(d) Fate of applied nitrogen in various soil types.

(15) CYTOGENETICS - Develop hybrid and hybrid derivatives useful to plant breeders in developing agronomically improved crops.

(16) GRAIN STORAGE - Insect physiology, taxonomy.

(17) BARANI AGRICULTURAL RESEARCH & DEVELOPMENT - N.A.

(18) CROP DISEASES RESEARCH INSTITUTE - No Response.

(19) NUTRITION & FOOD QUALITY

(a) Screening of new food commodities/food crop varieties for nutritional quality and consumer acceptance.

(b) Determination of the chemical composition of foods consumed in the country.

(c) Evaluation of antinutritional factors in foods.

(d) Development of new food products.

(e) Improving the keeping quality of chappati.

(f) Determination of cooking losses during cooking and processing of foods.

(g) To study the bioavailability of nutrients.

(h) Aflatoxin contamination of foods.

(20) LAND RESOURCES

(a) Use of labelled materials to trace in pathway of added plant nutrients. (b) Process of nutrient uptake. (c) Analytical techniques for analyzing soil and plant for macro and micro nutrients. (d) Research on N^{15} labelled materials under flooded soils will help in understanding various mechanisms of N losses from paddy fields, which will help in improving fertilizer use efficiency.

(21) RANGE & WATERSHED

(a) Development of growth based on models to predict changes in crops and natural resources.

(b) Resource based approach to delineation of agroecological zones.

(22) WATER RESOURCES

Irrigation efficiencies, uniformity coefficient, crop coefficient curves etc.

(23) SERICULTURE

Establishment of a seed production unit and research on production of hybrid seed for commercial rearing.

(24) HONEYBEE RESEARCH PROGRAM

Honeybee pollination potential of different varieties of crops.

(25) A- ANIMAL SCIENCES INSTITUTE

1. Techniques and various aspects of breeding, reproduction, health cover (eg. vaccine production through genetic engineering), embryo transfer etc.

B- MEAT

1. Preparation of nutritionally balanced and economical rations for beef and mutton production.

2. Basic studies on the chemistry and biochemistry of muscle to solve the toughness problem of meats.

C- ANIMAL HEALTH - In the field of livestock disease control, it is important to first understand the mechanism or pathogenesis of diseases. This falls under the basic research which is essential for applied research.

D- ANIMAL NUTRITION

1. Nutrient requirement of the animals.

2. Studies on the rumen ecosystem and digestive physiology of ruminants.

E- DAIRY CATTLE & CROSS BREEDING

Basic research on seasonability of breeding, long calving interval, poor expression of oestrus or silent heat, seasonability of sperm production, low concentration of sperms and hence much smaller number of semen doses prepared per bull/year for A.I.

F- SHEEP & WOOL

Exotic fine wool producing genes be introduced to native breeds of sheep of Kaghan valley of NWFP, Northern areas and Azad Jammu and Kashmir. Selective breeding be introduced in Punjab, Sind, Baluchistan and Peshawar valley in order to increase live weight and fleece weight without losing carpet quality of wool.

(26) TRAINING INSTITUTE - Relates to Research Programs.

(27) FARM MACHINERY INSTITUTE - Plant & animal physiology.

(28) COMPUTER & STATISTICS

(a) Data transformations.
(b) Non-parametric statistics.
(c) Determining statistical distribution of different biological phenomena.

(29) PUBLICATION & SCIENTIFIC INFORMATION - Not Applicable.

(30) AGRICULTURAL ECONOMICS RESEARCH UNIT

An organizational close linkages development systems of Agri. education, Agri. Research and Agri. extension to dissemination of economically viable, technically sound and administratively feasible technology upto the end users.

HOW CAN THE TIME GAP BETWEEN THE NEW FINDINGS AND ITS FIELD APPLICATION BE REDUCED?

1. EFFICIENT TECHNOLOGY TRANSFER/ INFORMATION SERVICES. ADDITION OF SCIENTIFIC AND EXTENSION STAFF IN THE PROVINCES. RESEARCH AT STATION AND THE FARMERS FIELD AND PROMPT VARIETY RELEASE. - 57%

2. THROUGH EFFECTIVE FSR AND SITE SPECIFIC IMPROVED TECHNOLOGY. - 46%

3. PUBLICITY, FIELD DAY, DEMONSTRATION, SEMINARS, LECTURES, LEAFLETS, BULLETINS, RADIO, TV. - 16%

4. PROGRESSIVE FARMER TRAINING AND INCENTIVE PROGRAMS. - 8%

.. ATTACH ANY ADDITONAL INFORMATION NEEDED TO DESCRIBE THE PROGRAMS AND ACCOMPLISHMENTS OF THE RESEARCH IN YOUR PROJECT OR SECTOR.

Note: The following are statements which represent abstracts of Questionnaire responses.

Total Programs = 37 Total Responses = 8 Percentage Responded = 22%

PLANT GENETIC RESOURCES

(1) Accomplished 16 plant collecting expeditions.

(2) Assembled and conserved 13500 accession of 26 crops.

(3) Evaluated and characterized 6000 accessions of cereal legumes and pulses etc.

(4) Supplied over 5000 samples of different crops to user community within country and abroad.

PLANT INTRODUCTION CENTRE

(1) Almost 2500 accessions of over 50 plants were imported from more than 30 countries. Some tropical legumes, plants like gauyule, buffalo gourd, ramie and some other plants of economic value proved very successful.

FODDER

(1) There should be strong linkage of fodder program with the advanced international institutes working on fodder crops like CIAT, ICARDA, ICRISAT etc. for putting the program on sound footings.

(2) Sound seed production system of fodder crops be developed for boosting the fodder production in the country.

NUTRITION & FOOD QUALITY

(1) We have set up a new animal room for evaluation of biological value etc. of food crops and other food commodities. This is a new facility and possibly does not exist any where in the NARS. We are also providing .research support service to the provincial and federal scientists. We are providing research facilities to post graduate students of the Agriculture Universities. We have recently produced date honey from different varieties of local dates.

HONEYBEE RESEARCH PROGRAM

(1) The European honeybee has recently been established in the country. It produced very high honey yield (average 18 kg per colony/annum) with the progressive bee keepers as compared with that of local hive bee (4 kg per colony/annum).

ANIMAL SCIENCES INSTITUTE

MEAT. In meat sector there is still lack of facilities for research and trained manpower which need be overcome by providing facilities and funds for research in this sector.

SHEEP & WOOL

Trained manpower and lab. facilities may be provided to bring about fruitful results.

TRAINING INSTITUTE

Uptill now NARC Training Institute through 82 courses/workshops has trained 2766 personnel accross the country. The recommendations of various conferences/seminars have always strongly advocated the establishment of "Pakistan Acedemy for Agricultural Sciences". It is the high time to think and upgrade the NARC Training Institute as an Academy.

Note: OILSEEDS and BARD :- Same response as for Q-3.

ADDITIONAL COMMENTS/SUGGESTIONS.

Note: The following are statements which represent abstracts of Questionnaire responses.

RESEARCH	*PERCENT
1. The objectives of the research to be done should be clearly determined.	15
2. Improve coordination with other institutes/universities and within NARC to avoid duplication in research.	12
3. Critical evaluation of the projects and statements/claims made by the scientists.	9
4. The Program/Project Leaders etc. should devote more time to research. Reduce extra load of paper work. Provide efficient support staff.	8
5. Provide lab. equipment like balances, big germinators, air conditioners (for seed stores), growth chambers, chemicals etc.	8
6. Provide more space for labs./offices.	7
7. Regular supply of water, gas and electricity in the labs. and provide power generators.	7
8. The grade conscious attitude among the scientists and research managers should be minimal.	7
9. Improve PSI building and provide store facilities, threshing yard etc.	5
10. Regular meetings to discuss results. Attendance compulsory for all scientists.	5
11. Update, enrich and organize the library properly. Display new arrivals regularly.	5
12. Research should not be meant only for papers/publications but for the most benefits of the farmers.	5
13. Establish efficient system for transfer of technology to farmers.	5
14. There should be important evaluation of a scientist each year by both internal & external experts. Program/Project Leaders should also be accountable for inefficiency of junior scientists.	4
15. Avoid "unfair" distribution of lab. facilities/equipment.	4
16. Allow scientists from other labs. to share lab. facilities.	4
17. Separate coordination from NARC research unit.	4

*Refers to the percent of sector scientists who agree with the given statement.

18.	Scientific staff should not be utilized in clerical or DPL's work.	4
19.	Pooling of specialized fields should not be done.	4
20.	Limit visits by outsiders/guests to avoid interruption in research work.	4
21.	Names of the actual (junior) workers" should be included as co-authors when results are published by Program/Project Leaders.	1
22.	PARC should pay membership fee of atleast one scientific society chosen by a scientist.	1
23.	Early clearance/payments of the imported biological materials compulsory.	1
24.	NARC conditions/environment is not suitable for breeding experiments. It is suitable for pathological and entomological research.	1
25.	Permanent allotment of experimental fields to each program.	1
26.	Field experimentation area among different programs should be distributed each year.	1
27.	Provide first aid kits to each lab.	1
28.	Construct more green houses.	1
29.	Construct boundary wall around NARC	1
30.	No interference with administrative powers of Project Leaders.	1
31.	Stop further enrolment of scientists. Technicians could undertake routine research.	1
32.	Conserve and strengthen working scientists. Stop study leaves, tours and give more attention to lab. work.	1
33.	NARC should be affiliated with Quaid-i-Azam University for higher studies.	1
34.	Shift Barani Agricultural College at NARC and provide research facilities/guidance to students.	1

FUNDS

35.	Provide more funds for research.	9
36.	All funds should be provided to coordinators for purchase/procurement of materials.	1

SUPPORT SERVICES/FACILITIES

37.	Complaints against Accounts, Administration (time delay factor and behaviour).	19
38.	Procurement system needs improvement for prompt and quality deliveries .	16
39.	Separate Ladies/Gents common room.	7
40.	Cafeteria is too small. Ensure availability of lunch even during "training courses" and "functions".	7
41.	A mosque should be constructed at NARC premises.	5
42.	Janitorial services in the Central Labs. need to be improved. Separate toilets for officers.	4
43.	The telephone system should be switched on in the labs.	4
44.	Establish a bank branch in NARC.	3
45.	Simplify procedure to avail transport facilities	3
46.	Stop misuse of small vehicles.	1
47.	FO & S needs further improvements for quick response of operations.	1
48.	NARC vehicle workshop needs improvement.	1
49.	The administration of NARC be dealt with locally so that PARC/NARC shuttle should stop.	1
50.	Involve Project Leaders when new appointments of supporting staff are made.	1
51.	A central computer link should be provided for easy access to central stores entries and supplies.	1
52.	Improve communication system (R&I)	1

INCENTIVES, PROMOTIONS, TRAININGS

53.	Simplify procedure for foreign training/higher studies. Selection on seniority and ability basis. Select junior scientists for long training.	23
54.	Due awards/medals should be given to scientists showing best performance.	11
55.	No distinction between married and unmarried officers for house requisition. Simplify procedure for house requisition.	4

56.	Rules of promotion - requirements of publications etc. should be clearly communicated to scientists in quantitative and qualitative terms and acted upon accordingly.	3
57.	Give research allowance to scientists.	3
58.	Office hours are too long.	1
59.	System of ACRs should be reviewed. Juniors should be allowed to see their reports and give comments.	1
60.	Promotions should be on the basis of research findings and publications and not on the basis of seniority.	1
61.	Invitations received directly by a scientist to attend national/ international scientific meetings should be honoured.	1
62.	Salary, medical and residential accommodation of staff may be pooled for budget purposes at NARC.	1

TRAINING INSTITUTE

63.	No chance was provided to avail any foreign training arranged by MART.	1
64.	Constitute a committee to simplify procedure to get approval for arranging training courses.	1
65.	We are still unable to avail help and assistance from Training Advisor MART Project.	1
66.	The Coaster IDB 2710 provided by MART should be returned to Director Training INstitute.	1

FARM MACHINERY INSTITUTE

67.	Office management staff should also be encouraged to undertake higher degree/diploma in related fields.	1
68.	The Directorship of the FMI should be on tenure-basis.	1
69.	Establish "Agricultural Engineering Research Institute (AERI)" instead of FMI for diversification of activities and more employment opportunities.	1
70.	Rotation of engineers to four sub-stations as a must for promotion.	1
71.	Management training to Directors, Coordinators, PIs etc.	1
72.	Projection/propagation of research results through mass media.	1

Total No. of Scientists = 208
% Responded = 36

Percent Time of Project/Program Leader Spent/Week

	Program/Project Leaders (32) Responses (Percent Time)		
	A (0 - 24) %	B (25 - 50) %	C (51 - 75) %
1. Administration	59	31	9
2. Research	25	47	28
3. Meetings, Tours, Seminars, Lib. etc.	34	50	16

Project/Sector Time Devoted to Different Types of Research

	Percent		
	A (0 - 25)	B (50)	C (75 - 100)
1. Basic Research	82	14	3
2. National Coordinated Programs	46	32	22
3. Other Applied Research	56	31	10

RESEARCH MANAGEMENT ITEMS

FORMAL PRESENTATIONS

NARC MASTER RESEARCH PLAN

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SUMMARY

Efficient research management is of vital importance for the success of research and attainment of the set objectives. Research management is virtually a full time job. It involves development of new projects alongwith budget preparation, procurement of equipments and chemicals. It also involves constant exchange of views/ideas/proposals with scientists working in the program/other related disciplines/provincial scientists/progressive farmers/international experts. The organization of national/international seminars in the discipline for the benefit of the scientists in the field is another desirable activity.

The program leaders, being research managers, are the key persons in formulation and implementation of research. The selection of program leaders is important from the point of view of professional ability, forward planning and implementation capacity via staff motivation, timely decision and guidance. The program leaders if allowed proper respect and freedom to plan and implement the approved program of work, can ensure progress. Set objectives for a research program can only be achieved if the program leaders enjoy full cooperation of research staff, administration and finance department.

The research work is formulated by the researchers, with the guidance of the program leaders. In case of coordinated projects, priorities for research are fixed after consultation with the members of the coordinated projects in the provinces. The work plans are discussed by the Technical Working Group (TWG) of NARC and the final approval is sought from the Technical Research Committe

CONSTRAINTS:

(1)	Shortage of qualified scientific/support staff	78%
(2)	Shortage/lack of apparatus, equipments, chemicals etc.	73%
(3)	Insufficient funds. Non-availability/delay in release of funds.	68%
(4)	Inadequate laboratory space/office accommodation	43%
(5)	Inadequate transport facilities.	32%
(6)	Inefficient and complicated procurement procedures.	30%
(7)	Non-availability of research literature in the library.	27%
(8)	Lack of incentives and awards to the scientists	16%

Note: Total number of speakers = 37

RECOMMENDED STRATEGY:

(1) Program/Project Leaders should be involved in the recruitment, career advancement, advance training and award of incentives to the staff.

(2) After the approval of research projects from the TWG and NARC Research Committees, group leader should be able to manage the requirement for research. Undue involvement of the accounts/finance branches in technical matter for providing the funds and raising undue objections in accounts matter should be discouraged.

(3) Program leaders should be given imprest money for making purchase of urgent nature.

(4) The Project leader heading the program should have the highest qualificaiton in that particular field.

(5) Proper incentives and promotions should be provided to the scientific staff. There should be set rules and regulations in the Council for recruitment, promotion and award of incentives for the scientists.

(6) The progress of each research project should be monitored by the team leader on the basis of duties assigned and the given manpower and the progress must be monitored in terms of research articles published on the research findings and the target achieved in relation to the objectives.

(7) Adequate resources in terms of operational funds, staff, equipment and other lab. facilities should be provided.

(8) Short term and long term trainings should be arranged on national and international levels so as to keep the researchers abreast of the latest research findings.

(9) Encourage participation of the scientists in the international conferences and seminars. Collaboration/ coordination at national and international level should be encouraged.

(10) Professional journals and books should be subscribed. Recent publications and reprints should be made available to the scientists without any delay.

(11) In order to carry out an effective on-farm research, provide adequate and reliable transport facilities.

(12) Procurement procedures should be streamlined to make it more efficient and responsive to the researcher's needs. There should be a committee of senior scientists authorized to supervise the procurement and procurement officer should be technical.

RESOURCE NEEDS:

(1) Manpower - more scientific and support staff	81%
(2) More funds	73%
(3) Lab. facilities - lab. space, equipment, computers, chemicals etc.	59%
(4) Transport facilities - vehicles	19%
(5) Recent literature - books, reprints etc.	14%
(6) Training facilities - short term and long term.	14%
(7) Encouragement to scientists	5%

Note: Total number of speakers = 37

DR. S. IQBAL AHMED, FARM MACHINERY INSTITUTE, DATED JANUARY 12, 1988

RESEARCH MANAGEMENT: The Program leaders are the key person in formulation and implementation of research. The approval of research in fact is in the hands of persons who have the money supply and policy control. The relationship between the program leaders and the policy makers and the money controllers are very crucial in registering the desired results. The selection of program leaders in important from the point of view of professional ability, forward planning and implementation capacity via staff motivation, timely decision and guidance. The program leaders if allower proper respect and freedom to plan and implement the approved program of work, can ensure progress. The policy makers may influence the program of work in the planning and approval stage. The money controllers may launch the appraisal mission at the time agreed during planning and approval process. The appraisal mission may relate the amount and pattern of expenditure with the results and this satisfy the audit requirements also. The recommendation of the appraisal missions in improving the implementations may receive serious consideration by the money controllers.

CONSTRAINTS: The constraints in recruitment, career advancement, incentives, awards, expenditure, movement of vehicles, communications, procurement and experimental equipment operational and repair services require serious consideration. The present situation has room for improvement.

RECOMMENDED STRATEGY: The opinion and recommendation of program leader may heavily weigh in the recruitment, career advancement, award of incentives to the support staff. The professional staff may be recruited evaluated and promoted on the recommendation of a committee composed of multi-disciplinary experts of national/international repute. To facilitate expenditure, the budget break-up should be considered as a guide only. The reappriation may be within the competency of the program leaders. Approval/sanction for any amount within the budgetary allocation may rest with the program leader. The appraisal mission comprising of scientists, policy makers, planners and financial experts may carryout the project evaluation which include audit. The vehicles movement is usually the most suspected mis-use and often quoted. The vehicle movement policy may take into consideration the situation under which the project/program of work is being implemented, the program leader is the best judge to decide and the appraisal mission is the appropriate evaluating body. The communications such as telephones, postage, telegrams etc. may be treated according to the strategy as noted for vehicles. The procurement and equipment operation maintenance may be such that researchers be tempted rather than forced to use. There are in fact services wherein professionalism may be promoted.

RESOURCE NEEDS: Research suffers the most when the funds allocated at the approval stage are reduced at a later stage. This frustrates the program leaders and the researchers loose hopes and confidence. Sudden bans on appointments add complications. Firm commitments and schedules release funds for research programs is the key to success. The industrial sector and large farmers may be potential funding source.

DR.MUMTAZ AHMED, BARD, DATED JANUARY 12, 1988

RESEARCH MANAGEMENT: The BARD Project presently operative under the discipline and guidelines provided in the "Long Term Work Plan" and "Annual Operational Plan" which are reviewed regularly by Coordination Committee, Steering Committee, BARD's Intrinsic self reviewing and Project Evaluation and Monitoring.

Regular in-house reviews before, during and at the end of a crop season are held. Each component leader and his colleagues are required to give regular briefs on their work to all the BARD scientists and management. A self critique is encouraged.

CONSTRAINTS:

1. Insufficient funds.
2. Non-availability of appropriately qualified manpower.
3. Lack of incentives.
4. Poor remuneration.
5. No long term human resource planning.

RECOMMENDED STRATEGY AND RESOURCES:

1. More training in scientific disciplines.
2. More training in research management.
3. Long term budgetary and resource planning.
4. Better and improved package of facilities and remuneration for scientists.

DR. S.M. MUGHAL, POTATO IN PAKISTAN, DATED JANUARY 19, 1988

RESEARCH MANAGEMENT: The research project is under the supervision of two committees (Supervisory and Technical).

SUPERVISORY COMMITTEE: It approves the project policy, assesses project progress and evaluates periodic work programs. The committee meets about every six months. Snschedule meetings are called at the request of the members with the approval of the Chairman of PARC. Its composition is as follows:

- Chairman, Pakistan Agricultural Research Council, Islamabad.
- Member (Crop Sciences) Pakistan Agricultural Research Council, Islamabad.
- One representative from each province.
- The Development Coordinator of the Embassy of Switzerland, Islamabad.
- Chief Technical Advisor, PSPDP, Islamabad.
- Project Coordinator, PSPDP, Islamabad.
- Representatives from the Agricultural Development Bank of Pakistan, Islamabad, Agricultural Marketing and Storage Ltd. (AMSL), Punjab Seed Corporation (PSC) and Potato Growers.

TECHNICAL COMMITTEE: It meets 2-3 times a year and discusses all the technical work plan, which is then submitted to Chairman, Supervisory Committee. Its composition is as follows:

- Member (Crop Sciences) PARC, Islamabad (Chairman)
- Chief Technical Advisor, PSPDP, Islamabad/
- Project Coordinator, PSPDP, Islamabad
- Director/Potato Botanists from the Provincial Agricultural Research Institutes.
- Director (Planning), PARC, Islamabad.

The Project Management consists of the project Coordinator and the Chief Technical Advisor, who work together in the operation and management of the project in order to achieve project objectives.

Project Coordinator manages the project, plan and supervise the Potato Development Programs and activities, coordinates with all the concerned agencies, exercises budgetary control and compile periodical reports. He works closely with CTA and other member of the project. CTA is fully responsible for the Swiss side. The regular in-house review and the evaluation of the project is done by the above committee alongwith members nominated by the Ministry of Planning and Development and progressive farmers from various provinces.

CONSTRAINTS: The two main constraints are: non-availability of appropriate, trained and qualified manpower in various aspects of potato crop (physiology, Breeding, Post harvest Technology and Socio-economics) and insufficient funds. Other constraints include: lack of encouragement and incentive to the scientists, recruitment of personnel and career development.

RECOMMENDED STRATEGY: The recommended strategy should include: Development of an efficient system of management (Administration, finance and logistics) with particular emphasis on technical work (implementation, evaluation and production). Research work done in the past must constitute strong base for future studies. Therefore, Project Leader, with his highest qualifications, experience and reputation, should be a good Research Manager who is also involved in recruitment, policies, decisions, career development, periodic advance training and over all in-service professionalism.

RESOURCE NEEDS:

- Establishment of a "National Institute for Potato Research" with well equipped laboratories and stations in various ecological zones of Pakistan. This will intensify research and development on vertical and horizontal lines.

- Provision of adequate funds, granted on long term budgeting and planning.

- Development of trained manpower in various aspects of potato.

- Encouragement to scientists.

DR.AZRA QURESHI, TISSUE CULTURE, DATED JANUARY 19, 1988

RESEARCH MANAGEMENT: The program leaders are the research managers. It is imperative that they are actively involved at every stage and are given any such liberty as might be useful to accelerate the pace of their research.

CONSTRAINTS: Dearth of trained manpower and inadequate funds could be the most serious constraint in the pursuit of scientific objectives. Transport could be another, because mobility from the laboratory to related organizations is tremendously constrainted, primarily because certain programs are not allotted vehicles and secondly the number of vehicles is inadequate in the NARC pool. Consequently, the outstation experiments have to be planned subject to the availability of vehicles. This seriously interteres with the scientific work. Glass houses continue to be an important constraint. The present laboratories are not designed according to the needs of the scientists. Unavailability of rare chemicals in time not only retards the speed of work, but also a lot of precious time is wasted.

RECOMMENDED STRATEGY:

1. Program Leader handling the program should have the highest qualification in that particular field.

2. As the program leaders are actively involved in finance and administration they should be encouraged to attend relevant short term training courses both at home and abroad.

3. Leadership training workshops could be arranged at the national level.

4. Program leaders should be consulted while advertising positions for new recruitments.

5. The budget estimates submitted by the program leaders should be viewed realistically, and no cuts made by the accounts section without their consent.

6. Accounts should assist program/project leaders while budget estimates are prepared.

7. Automatic generators should be connected not only to the central lab system but also to the glass houses.

8. Scientists desirous of working during late hours and during the weekend should be given transport facility on priority basis.

9. If possible one rest room is earmarked in the central lab system where the scientist can even rest if the experiments planned require their presence overnight.

10. Coolers and tea/coffee stands be arranged in the corridor of central lab system.

11. The central lab system should be immaculately clean. More janitors can be employed and if possible one each is detailed for each wing of the lab. Dusting cobwebs and cleaning glasses should be taken care of by the administration.

12. There should be a system to purchase imported chemicals which can turn out to be cheaper and more reliable.

RESOURCE NEEDS:

1. Manpower

2. Funds

3. Equipment

DR.H.I.T. KHAWAJA, CYTOGENETICS, DATED JANUARY 19, 1988

4.0 RESEARCH TEAM

1. The Research work plan (experiments etc.) are laid down in good time after thorough discussion and full involvement of the relevant researcher within the group.

2. The resources require to execute the research are organized well in advance.

3. The research is supervised by the programme leader physically and technical assistance is extended where needed.

4. The data are recorded as they come and compiled and analysed as as soon as they are ready.

5. The research findings are presented by all recognized means of scientific communications.

4.1 CONSTRAINTS

1. Non availability of predetermined finance.

2. Inadequate human resources.

3. Lack of well established reference library.

4. Insufficient green house space and non availability of growth room or chambers.

5. Inadequate laboratory space.

6. Need for some laboratory equipment.

7. Need for annual review of organizational aspects of certain arrangements directly related to research management such as allotment of green house space and constitution of TWG.

4.2 RECOMMENDED STRATEGY

1. The programme should be included in the non developmental side with adequate yearly budget.

2. Planning for human resources:-

To begin with programme may have atleast 8 scientists two of which should be sent abroad for Ph.D. From 10 to 12 yearly time the unit should have atleat 8 Ph.Ds.

4.1 RESOURCE NEEDS.

1. Finance.
2. Human resources.
3. Lab. space and equipment.
4. Green houses (atleast 3)
5. Growth room or chambers (walk in type).

DR.MOHAMMAD ASLAM, CDRI, DATED JANUARY 26, 1988

RESEARCH MANAGEMENT: All the proposed research is to be cleared by the concerned technical working group as well as NARC Research Committee.

CONSTRAINTS:

1. Manpower: It is intended to have at least 50 research scientists working in the institute by the year 2000.

RECOMMENDED STRATEGY - Recruitment of trained personnel.

2. Lack of data base:

RECOMMENDED STRATEGY - Procurement of computers.

3. Fragmentation of various disciplines of Plant Pathology:

RECOMMENDED STRATEGY - Integration of all disciplines related to to phytopathology into the institute.

4. Inadequate of Monitoring of Plant Diseases:

RECOMMENDED STRATEGY - Provision of better logistic facilities.

DR.S.M. MUGHAL, PLANT VIROLOGY, DATED JANUARY 26, 1988

RESEARCH MANAGEMENT

Research work is conducted, organized and managed by 5 scientists, and collaborated with commidity programmes (Potato, Sugarcane, Vegetables, Pulses) and other disciplines (Pest Management, Weed Science, Animal Science and Federal Seed Certification Department). A close collaboration is maintained with the provincial institutes for the exchange of antisera, seeds of indicator and propagative hosts and virus isolates and strains.

CONSTRAINTS

Operational funds are inadequate and laboratory space is also limited. There is no animal house to raise animals and to produce antisera. The glasshouse is lacking a soil-sterilization unit. The laboratory is not air-conditioned and contamination is the usual problem. Some more equipment is required to advance the work on viral proteins and nucleic-acids.

RECOMMENDED STRATEGY

The recommended strategy should include: Development of efficient system of management and research implementation. Research work is a continuous process and therefore, sufficient funds must be allocated. Project leaders should be involved in recruitment, policies, decisions, career development, periodic, advance training and over all inservice professionalism.

RESOURCE NEEDS

Provision of sufficient funds, adequate laboratory space and cold room will greatly strengthen the programme. Literature, particularly the scientific journals are also required. Teaching of Plant Virology at the Graduate and Post-graduate in the Agriculutral Universities can develop manpower in this discipline.

DR. RASHID AHMED SHAD, WEED SCIENCES, DATED JANUARY 26, 1988

RESEARCH MANAGEMENT:

Constraints:

1. The program is so far on the development side.
2. Shortage of trained manpower.
3. Shortage/lack of research equipments.
4. Shortage of space (greenhouse, lab)
5. Shortage of funds
6. Shortage of vehicles.

RECOMMENDED STRATEGY:

1. Weed Science program should be established on the non development side. It is suggested to establish a National Weed Science Research Institute or it could be called Weed Science Division of NARC comprising of 4 different disciplines.
2. Research equipment, green house/lab facilities should be extended.
3. Training facilities (long, short term) should be enhanced.
4. Encourage participation of the scientists in the internationai conferences/seminars.
5. Literature on weed science should be made available.
6. Collaboration/coordination at national and international level be encouraged
7. Support activities of Pakistan Weed Science Society.

RESOURCE NEEDS:

Manpower:	CSO	= 1
	PSO	= 2
	SSO	= 4
	SO	= 8
	Lab/Field Asstts/Technician	= 6
	Secretariai Staff	= 3
	Other supporting contingent staff	= 8

Training Facilities:

Ph.D	= 5
Short Terms	= 10

DR. RAFIQ AHMED, APICULTURE, DATED JANUARY 26, 1988

RESEARCH MANAGEMENT: Program leaders, being research managers, are the key persons in implementation of thier research programs. They should be particularly involved in administrative matters concerning their program so that they should be definite authority to accelerate the pace of their research.

Implementation of Honeybee Research Program has been reviewed by the top most world authorities in beekeeping in the past. This sort of reviews are more useful in maintaining the research standard and need to be continued.

CONSTRAINTS:

1. In addition to federal and provincial institutes, training program needs to be further extended to most of the beekeeping areas.

2. Modern beekeeping equipment (comb foundation machines) and some chemicals (medicines) are not easily available in market.

3. The nucleus colonies of A.mellifera bees are very expensive.

4. A.cerana bees with most of the bee keepers are almost wild and require improvement or replacement with the high honey yielding strains.

RECOMMENDED STRATEGY:

a. Most of the beekeeping staff have not been exposed to advanced beekeeping in any foreign country. They need advanced training in the subject and should be sent for short training abroad.

b. PARC policy framed for recruitment of staff particularly below 16 BPS should be strictly implemented by involving the project leaders in the recruitment of field staff.

c. Budget head needs to be reduced for lesser reappropriation to facilitate working of scientists in implementing their programs.

RESOURCE NEEDS

a. Staff

Present Position:

Chief Scientific Officer (B-20)	Part Time 1
Principal Scientific Officer (B-19)	Full Time 1
Scientific Officer (B-17)	Full Time 2

Additional Requirement:

Assistant Scientific Officer (B-16)	Full Time 1

b. Budget: Starting with Rs.0.950 million during 1988-89, increasing at the rate of 0.050 million per year.

c. Equipment:

1.	Honey processing plant	Rs.0.250 million
2.	Royal jelly extract pumps	Rs.0.075 million
3.	Propolis harvesters and processors.	Rs.0.050 million
4.	Comb foundation machiens	Rs.0.080 million
	Total:	Rs.0.355 million

DR.RAFIQ AHMED & MR.RIAZ KHALID SIDDIQUI, SERICULTURE, DATED JAN 26, 1988

RESEARCH MANAGEMENT: This program is short of staff. Therefore research has been restricted to a few aspects of sericulture.

CONSTRAINTS:

a. The sericulturists have little knowledge of modern sericulture technology. Therefore, they need some training in various sericulture practices.

b. Modern sericulture equipment such as cooled incubators, cocoon drier and reeling machine are essentially required in research.

c. Sericulture laboratory for rearing pure lines and producing and storing eggs is needed in order to implement this program on sound scientific basis.

RECOMMENDED STRATEGY: Sericulture research staff have not been exposed to advance sericulture in some foreign country. They need advance training in the subject and should be sent for training abroad.

Sericulture program should be included in non-development program of NARC.

RESOURCE NEEDS:

Staff: Additional Requirements;

Scientific Officer = 2

Budget:

Rs.0.200 million during 1988-89, with an increase of Rs.0.025 million every year.

Equipment:

1.	Cooled incubator	Rs.0.080 million
2.	Incubator	Rs.0.050 million
3.	Cocoon drier	Rs.0.020 million
4.	Reeling machine	Rs.0.060 million
	Total	Rs.0.210 million

DR. M. SALIM, LAND RESOURCES, DATED FEBRUARY 02, 1988

RESEARCH MANAGEMENT: The development and funding of research projects is handled by the NARC. Once a project is approved, research management becomes the responsibility of NARC. At present the research work of each project is discussed in the Technical Working Group (TWG) on Land and Water Resources. The experiments to be conducted in rabi and kharif seasons are discussed by the TWG before initiation of the respective crop season. Final approval of research program for each season is accorded by the NARC Research Committee.

The operation and composition of TWG is quite useful and helpful for the improvement of research activities at NARC. However, the discussion of research programs of each disciplines in the NARC Research Committee has certain questions/observations. In brief the suggestions in this regard are listed as under:-

- Since the NARC Research Committee is composed of scientists of diverse disciplines, discussion of individual research experiments at this forum may not be helpful in improving the quality of research.

- The composition of TWG can be improved by including prominent soil scientists working in other organizations.

- The discussion of experiments for each season in time consuming and mostly delays in the execution of research. Therefore, this practice may be restricted to once a year by planning experiments for rabi, kharif and spring season.

CONSTRAINTS:

- Funding of program is not sufficient.

- Glasshouse space is insufficient.

- Sufficient quantity of distilled/deionized water for laboratory and greenhouse work is not available.

- There is no space/facility for the preparation and storage of soil and plant samples.

- Boron free glassware not available.

- Lack of key equipment viz: Facility for chromatography, gas chromatography, HPLC spectrophotometer (U.V), fraction collectors, cold room is urgently needed.

- Trained manpower for each research discipline is the urgent need. Especially there is no SO and SSO in management of flooded rice soil.

RECOMMENDED STRATEGY: For conducting "a class" quality research at NARC following needs to be done:-

- Well trained scientists should be goven the responsibility of conducting research in a particular discipline.

- Senior scientist should be given the opportunity to conduct research with scientists of international repute for atleast 6 months at international research centre/universities and this practice should be repeated after every three years.

- After the approval of research projects from the TWG and NARC research committee, group leader should be able to manage the requirements for research. Undue involvement of the account/finance branches in technical matter for providing the funds and raising undue objections in account matters should be discouraged.

- Program leaders should be given impressed money for making purchases of urgent nature.

- Team leader should also be impowered to recruit the supporting staff according to his requirement and the NARC administration should just keep their record.

- The senior scientist conducting research on various research projects should be able to get the manpower according to his requirement and the group incharge should help and assist to arrange the genuine requirements of the pear scientists.

- Present system of procurement is awfully time consuming and complicated. Also the procurement officer is non technical so it is difficult for him to purchase quality chemicals and other laboratory items. It is suggested that their should be a committee of senior scientist authorised to supervise the procurement and procurement officer should be technical.

- The progress of each research project should be monitored by the team leader on the basis of duties assigned and the given manpower and the progress must be monitored in terms of research articles published on the research findings and the target achieved in relation to the objectives.

- There should be a system for appreciating the good work of the scientists on the basis of facilities provided to them.

- There should be set rules and regulations in the council for recruitment, promotions and award of increments for the scientists.

RESOURCES NEEDS:

- Sufficient funds for the research projects:

Manpower (CSO=1, PSO=1, SSO=5, SO=7, Supp.Staff)	=	Rs. 20.9 million
Operational Funds	=	Rs. 15.1 million
Training (6 Long Term, 5 Short Term)	=	Rs. 12.0 million
Total:	=	Rs. 48.0 million

RESOURCE NEEDS:

A- Soil Fertility & Plant Nutrition.

Funds Required (Manpower, Operational Funds, Trainings) = Rs.48.0 M

B- Management of Flooded Rice Soils.

Funds Required (Manpower, Operational Funds, Trainings) = Rs.36.9 M

C- Soil Chemistry & Mineralogy.

Funds Required (Manpower, Operational Funds, Trainings) = Rs.31.2 M

D- Soil Biology.

Funds Required (Manpower, Operational Funds, Trainings) = Rs.36.3 M

E- Stress Physiology.

Funds Required (Manpower, Operational Funds, Trainings) = Rs.35.9 M

F- Soil Physics.

Funds Required (Manpower) = Rs.13.1 M

- Adequate well trained manpower in various disciplines.
- Adequate glass house space with head house facility
- A large capacity water still/deionizer.
- Spare parts of major equipments.
- Boron free glassware.
- Power generator for laboratory equipments.
- Power stabilizers for the sophisticated equipments.

DR. A. Y. RANJHA, WATER RESOURCES, DATED FEBRUARY 02, 1988

[illegible]

RESEARCH IS CONDUCTED BY THE NRS SCIENTISTS. EXPERIMENTS ARE DESIGNED UNDER EACH PROJECT BY THE RESPECTIVE PRINCIPAL INVESTIGATOR KEEPING IN VIEW THE PARC NATIONAL POLICY AND PRESENTED TO THE PROJECT INCHARGE (PI). AFTER THOROUGHLY SCREENING THE EXPERIMENTS, THE PI PRESENTS THE EXPERIMENTS TO HIS TECHNICAL WORKING GROUP (TWG) FOR APPROVAL. ONCE THE TWG HAS APPROVED THE EXPERIMENTS THEN THEY ARE PRESENTED IN THE NARC RESEARCH COMMITTEE FOR THEIR FINAL APPROVAL. AFTER THE FINAL APPROVAL OF THE NARC RESEARCH COMMITTEE, THE RESEARCH IS CONDUCTED. A MONTHLY PROGRESS REPORT FOR EACH PROJECT IS WRITTEN AT THE END OF EACH MONTH. BY THE END OF A YEAR, AN ANNUAL REPORT FOR EACH PROJECT IS COMPILED COVERING RESEARCH RESULTS OF ALL THE STUDIES CONDUCTED UNDER EACH PROJECT.

CONSTRAINTS:

1. Inadequate budget.
2. Inadequate Technical manpower. (Ph.D = 5, M.Sc = 7, B.Sc = 12)
3. Unreliable transport facilities due to old and outdated vehicles.
4. Insufficient lab. equipment and still availability of equipment through MART Project is awaited.

[illegible]

A PROJECT INCHARGE SHOULD HAVE MORE FREEDOM TO BUY THE EQUIPMENT NEEDED AND THE COMPONENTS REQUIRED FROM TIME TO TIME. HE SHOULD HAVE MORE IMPREST MONEY AT HIS DISPOSAL TO BUY CERTAIN ITEMS WHICH MIGHT BE SUDDENLY NEEDED. TO QUOTE AS AN EXAMPLE, IN OUR WRS WE MIGHT SUDDENLY NEED A PIECE OF PIPE, A FEW SOCKETS, REPAIR OF AN ENGINE, A PUMP, AN ELECTRIC MOTOR AND/OR A FEW TOOLS TO WORK WITH OUR IRRIGATION SYSTEMS SUCH AS SPRINKLER AND TRICKLE. WE CANNOT RUN AFTER THE PROCUREMENT PERSONNELS TO ACQUIRE SUCH SUDDENLY NEEDED COMPONENTS. A PI MUST HAVE ENOUGH FUNDS AS IMPREST MONEY AT HIS DISPOSAL TO BUY SUCH SUDDENLY NEEDED ITEMS AT ODD HOURS.

RESOURCE NEEDS:

- More funds are needed in the WRS to conduct research for producing tangible results.
- More highly qualified manpower is needed in the WRS.
- We need better and dependable transportation for touring to other sites.
- More lab. equipment is needed for our water lab. to conduct different lab. research studies.

DR. M. AKMAL KHAN, NUTRITION & FOOD QUALITY, DATED february 09, 1988

RESEARCH MANAGEMENT: Research management is virtually a full time job. It involves development of new projects alongwith budget preparation. Procurement of new research equipment and speciality chemicals is another important feature which is essential to bring/maintain the laboratories to international standards. It also involves constant exchange of views/ideas/proposals with scientists working in the program/other related disciplines/provincial scientists/progressive farmers/international experts etc. The organization of national/international seminars in the discipline for the benefit of the scientists in the field is another desirable activity.

CONSTRAINTS:

1. Shortage of qualified scientists and ASOs and lab. attendants.

2. Inefficient procurement procedure.

3. The library facilities are not upto date.

4. There is no vehicle allocated to this program.

5. Adequate in-service training facilities are not available for senior scientists.

6. A full fledged animal house facility is not available for bio assays.

RECOMMENDED STRATEGY:

1. The food quality and oil quality sections should be headed by scientists at the SSO level who hold Ph.D degree in food science/food technology/grain science and biochemistry/nutrition with specialization in oilseeds.

2. Five posts of ASOs should be sanctioned for this program who should be M.Sc.s in food science/food technology/biochemistry/nutrition/home economics and they should be allocated to the respective sections on the basis of their academic background and experience.

3. Four posts of Lab. attendants should be created urgently for this program.

4. The method for procurement of chemicals, glassware etc. is too cumbersome, lengthy and unsatisfactory at the moment and there is a great need for its improvement.

5. A vehicle should be allocated to the program.

6. Adequate promotion/career advancement opportunities be provided to senior scientists. A scientific service of Pakistan on all Pakistan basis should be created providing sufficient opportunities for time-scale promotion upto BPS-22.

7. Adequate sabbatical leave/in-service training facilities of 6-12 months duration at international centres of excellence every three years should be provided to senior scientists of this program.

8. A full-fledged animal house facility should be developed at NARC on a priority basis.

RESOURCE NEEDS: The limited availability of funds in an important restraint against further expansion and initiation of new projects. Since many foreign donor agencies are not interested in projects which are of greater importance to the country, the Government of Pakistan should be approached to allocate a higher percent of GNP to research than is the case at present. Furthermore, foreign donor agencies e.g. FAO, World Food Program, United Nationals University etc. should also be approached for funding/technical assistance for this program. The ultimate aim should be to upgrade these laboratories into a National Institute of Food Science and Nutrition. To start with, the budget of this program needs to be doubled to enable us to initiate action on the proposed objectives of the Master Research Plan of NARC in respect of this program.

DR. NOOR MOHAMMAD, RANGE & AGRO FORESTRY, DATED FEBRUARY 09, 1988

RESEARCH MANAGEMENT: The research work is formulated by the researchers with the guidance of the program leader, which is discussed by the Technical Working Group of NARC. The final approval is sought from the Technical Research Committee. However, the relationship between the policy makers and the finance department is much essential to conduct the research in smooth and progressive manner. The program leader is the key person. He can only ensure progress if he enjoys the cooperation of research staff, administration and finance department.

CONSTRAINTS:

- Shortage of manpower
- Lack of vehicle
- Lack of lab. equipments.
- Budget
- Complicated procurement procedures
- Lack of coordination within institution
- Literature

RECOMMENDED STRATEGY: As the program leader is the key person of a research project, his recommendations must be put forth for the recruitment of research staff. Sufficient research staff is much necessary to run the research projects successfully. Only the program leader can suggest the proper person to be included in his research staff. The modus operandi of procurement must be simplified so as to obtain the research equipment etc. well in time. Short term and long term trainings should be arranged on national and international level, so as to keep the researchers abreast of the latest research findings. A field vehicle is necessary to work in the field properly.

RESOURCE NEEDS:

1. Manpower (Ph.D = 4, M.Sc = 8)

2. Funds needed (Salary = Rs.45.0 million, Operational funds = Rs.18.0 M)

DR. PARVEZ NAEEM, REMOTE SENSING, DATED FEBRUARY 09, 1988

RESEARCH MANAGEMENT: Research managers should be given management training. Preferably by the Pakistan Institute of Management. Input of research leaders should be solicited for recruitment of staff for his/her project.

CONSTRAINTS:

(1) Lack of trained manpower
(2) Lack of Equipment
(3) Lack of appropriate lab space
(4) Lack of transport (ground & air) for survey.
(5) Lack of literature
(6) Too much file-work

RECOMMENDED STRATEGY:

- Hiring of fresh graduates and training them in and outside the country.
- Purchase of equipment compatible with that of SUPARCO.
- Construction of dust free temperature controlled building to house sophisticated electronic equipment.

- Provision of 2 vehicles and a small aircraft.
- Purchase of at least 4 leading journals in the field.
- Streamlining of the working of the higher level management that should reduce the file-work by scientists.

RESOURCE NEEDS:

1. Local & F.E. Components (Rs. 24.0 million
   $ 00.81 million

2. Manpower (Ph.Ds = 3, M.Sc. = 6, Draftsmen = 2, Technicians = 1)

DR. M. ASHRAF, HORTICULTURE, DATED FEBRUARY 23, 1988

RESEARCH MANAGEMENT: Horticulture crops research program fixes its priorities for research in consultations with the members of coordinated projects in the provinces and the progressive growers. It also keeps in view the economic value of the crop and the economic impact of outcome. The research experiments are discussed in Technical Working Group (TWG) and finally in Research Committee at NARC and approved. It is recommended that the meetings with coordinating units be more frequent.

CONSTRAINTS:

- Limited staff (scientific and support) and funds.
- Limited office and lab. space.
- Very limited laboratory equipment.
- No facility for controlled environment greenhouse and seed store.
- Procurement system badly hinders progress.
- Lack of vehicle facility for field work.

RECOMMENDED STRATEGY:

- Identification of problem and needs of sector and goals oriented projectization.

- Meaningful and effective coordination of resources and manpower within the country.

- Efficient collaboration with centres/Institutes of International importance for transfer of modern research/production technologies and scientific materials.

- Provision of resources-trained manpower, lab. equipments, materials, funds and infrastructure.

- Simplification of procurement procedures and making the system more effective.

- Saving the scientists from unscientific persuits and distractions at the centres.

- Motivation and incentives for higher proficiency and achievements.

RESOURCE NEEDS:

- More scientific and support staff is urgently needed to tackle with the (agronomy SSO 2, SOs 8), (Crop Breeding SSO 2, SOs 7),(Plant Protection SOs 2),(Crop Physiology SOs 2), (Postharvest Physiology SOs 2), (Biotechnology SOs 3), (Propagation SO 1).

  All the SSOs must be holding Ph.D degrees whereas SOs with M.Sc. degree.

- Laboratories, equipment and office space is accordingly needed.

- Controlled environment greenhouse and a controlled environment seed store is an absolute necessity for plant breeding trails.

- Working funds need to be enhanced accordingly.

MR. RASHID ANWAR, PLANT GENETIC RESOURCES, DATED FEBRUARY 23, 1988

RESEARCH MANAGEMENT:

- The Plant Genetic Resources Program fix priorities for exploration and collection of crop germplasm in consultation/collaboration with crop commodity coordinators, International Board for Plant Genetic Resources.

- The research experiments on various aspects of Plant Genetic Resources i.e. exploration, collection, evaluation etc. are discussed in Technical Working Group NARC/PARC.

- It would be more appropriate to formulate Technical Advisory Committee on each crop including crop commodity coordinator and a crop specialist from each province. The committee should meet once or twice a year to discuss various aspects of crop germplasm. The involvement of provincial scientists will enhance the utilization of crop germplasm.

CONSTRAINTS:

- Limited staff (scientific & support) and funds.
- Limited space for laboratories and processing of seed samples.
- Limited space for storage of germplasm.
- Limited lab. equipment.

RESOURCE NEEDS:

- Genebank (short, medium and long term storage) for preservation of crop germplasm.
- Labs. for seed processing, viability testing, documentation and seed health offices for scientists and staff are needed.
- More staff, funds and vehicles.
- Green house/screen house for multiplication and rejuvenation of cross pollinated crops.
- More equipments for lab. and a computer for documentation.

DR. ZAHOOR AHMED, PLANT INTRODUCTION, DATED FEBRUARY 23, 1988

RESEARCH MANAGEMENT: Presently the research management is through TWG and research committee. But it is proposed to have different advisory committees which should meet at least twice a year and advise what to introduce and what not.

CONSTRAINTS:

1. Complicated import procedure.
2. Shortage of manpower and necessary equipments for evaluation and post entry quarantine.
3. Lack of financial resources.

RECOMMENDED STRATEGY:

1. The procedure to import plant material should be simplified.

2. PIC should be exempted from Import Permit.

3. Necessary foreign exchange should be available with the program to procure the plant material from abroad.

4. The scientists should be provide chances to develop contacts with other scientists outside the country which help in the exchange of plant material.

RESOURCE NEEDS:

1.	More scientific staff:	Pathologist, Horticulturist, Entomologist, Agronomist.
2.	More equipments, lab. and other facilities.	Equipments for seed health, one green house for screening and post entry quarantine, more space etc.
3.	More financial resources:	Salaries for additional staff, operational budget etc.

DR. AHMED MUSTAFA KHAN, SUGARCANE, DATED FEBRUARY 23, 1988

RESEARCH MANAGEMENT: Research management is virtually a full time job. It involves development of new projects alongwith budget preparation. Procurement of new research equipment especially chemicals is another important feature which is essential to bring/maintain the laboratories to international standards. It also involves constant exchange of views/ideas/proposals with scientists working in the program other related disciplines/provincial scientists/progressive farmers/international experts etc. The organization of national/international seminars in the discipline for the benefit of the scientists in the field is another desirable activity.

CONSTRAINTS:

- Shortage of qualified scientists in the program.
- There is no lab. facility for sugarcane.
- The procurement procedures are too cumbersome, lengthy, inefficient and outdated.
- The lib. facilities are not up-to-date in respect of books and journals regarding sugarcane.
- Adequate in-service training facilities at leading centres of excellence are not available for sufficient period for senior scientists/junior scientists.

RECOMMENDED STRATEGY: A Project Incharge should have more freedom to buy the equipment needed and the components required from time to time. He should have more imprest money at his disposal to buy certain items which might be suddenly needed.

The lib. facilities for sugarcane crops should be brought up-to-date. Adequate in-service training facilities of 6-12 months duration at international centres of excellence after every three years should be provided to senior scientists of this program.

RESOURCE NEEDS:

- More funds are needed to strengthen the program.
- More highly qualified manpower is needed in sugar crops.
- There is need for one Ph.D. in sugarcane breeding and one in sugarcane physiology. Moreover, one sugarcane disease specialist is also needed.

MR. M. BASHIR, PULSES, DATED FEBRUARY 23, 1988

RESEARCH MANAGEMENT: A profound reorientation of agricultural research has taken place in many developing countries during the past 30 years. To accelerate the output of research results the developing countries are shifting from the traditional organization of research by disciplines (plant breeding, soil research, pathology, agronomy, entomology, economics and quality etc.) to coordinated commodity research projects.

A coordinated, national, multidisciplinary research project is a powerful means for producing technology that can raise yields and small farmers income. There are four essential elements of an effective coordinated research project.

a. Research is carried out in all areas of the country where the crop is important.

b. A nationally respected and competent scientists leads the project.

c. All scientific disciplines important to the development of new technology for the crop are encompassed.

d. Production problems are the focus of the project.

In coordinated research projects the emphasis is placed on developing technology for higher and more efficient production and solving problems that limit yield increases on other words, the project focus on production oriented research.

RESEARCH IN A NATIONAL CROP RESEARCH PROJECT: Generally a national crop research project has two broad responsibilities (i) varietal development and (ii) improvement of crop management practices. Varietal development requires a multidisciplinary plant breeding team to produce crop varieties, whereas crop management research should produce package of improved production technology to be adapted by the growers.

CONSTRAINTS: Lack of trained manpower and inadequate funds could be the most serious constraint to achieve the objectives or goals of the projects. Non-availability of latest literature in the library, shortage of green houses, space allocation for scientists in crop sciences institute (CSI) and independent movement of the project leader are also hurdles in achieving the objectives. The present procurement procedure also needs improvements.

RECOMMENDED STRATEGY:

1. The coordinator or leader should be professionally competent and unbiased scientist.

2. The research should be production oriented its goals to develop technology for raising yields per hectare and increasing the rural income should be well defined.

3. All scientific specialities necessary to develop a complete and economically sound technology should be represented in the project (multidisciplinary project).

4. Research should be initiated in each major agro-ecological zone in which the crop is important or is expected to have high potential.

5. Involvement of scientists in un-necessary paper work should be minimized.

6. Monitoring and evaluation of research progress on annual basis.

7. Research findings are being made known to administrators planners the extension service and farmers.

8. The project develops strong links with international research institutes and other national research programs.

9. Existing facilities of greenhouses are inadequate, it needs improvement.

10. A system should be developed to have a strong coordination among the various program at NARC.

RESOURCE NEEDS:

1. Trained manpower in various disciplines like breeding, pathology, physiology, agronomy, entomology and quality is required.

2. Adequate funds are required to rear the program on sound footings.

3. Equipment and green house facilities are needed e.g. a separate green house is required for screening against chickpea blight and other important diseases of legume crops.

MR. MOHAMMAD ASLAM, OILSEEDS, DATED FEB. 23, 1988

RESEARCH MANAGEMENT: The Program Leaders/Coordinators are most logically the research managers of their respective programs. They should have all powers for operational management.

CONSTRAINTS:

-- Lack of leadership or program incharge.
-- Lack of trained manpower on each oilseed crop.
-- Lack of office space, cold rooms, field lab. facility and field equipment to facilitate efficient planting and harvesting of experiments.
-- Lack of proper coordination due to shortage of funds.

4.2 RECOMMENDED STRATEGY

- Improve marketing system and ensure the dispusal of farmers' produce.

- Increase support price.

- Appropriate policy measures should be taken to develop adequate domestic and export market for Oilseed meal as poultry and livestock feed.

- Establish an institute at federal level on oilseed crops which should be responsible for all the activities related to the crop development and research work.

- Adequate germplasm collections should be built up in all major oilseed crops to provide gene sources for early maturity, drought tolerance, pest and disease resistance and high oil content. For some oilseed crops, the researchers still relying on finished exotic products which limits their scope for selecting better adapted varieties.

- In addition, to higher seed yield, emphasis should also be given to the high oil content and improved oil quality, disease and pest resistance in varietal development programmes.

- Disease and pest management research staff should be placed in the programmes for effectiveness and better plant protection research results.

- Specific situations for which suitable production technologies are not available should be clearly identified and appropriate research focuses provided for the development of such technologies.

- Appropriate on farm research should be conducted to develop farming systems for cultivation of oilseeds. Such on farm research should particularly focus on economics of oilseeds cultivation.

- The Agricultural Machinery Institutes should make special efforts to introduce/develop machinery needed for oilseed production.

- Efforts should be made to develop multi-purpose machines to reduce investment on farm machinery.

RESOURCE NEEDS:

Manpower: Existing = 2 Ph.D + 5 M.Sc
Required = 13 Ph.D + 26 M.Sc

DR. M. ASHRAF, RICE, DATED FEBRUARY 25, 1988

RESEARCH MANAGEMENT: NARC Master plan will be better developed if following are discussed at this forum and resolved:

a. How NARC should proceed to conduct environmently focused research in environments not found near its HQ at Islamabad.

b. What additional mechanism should be developed to foster greater cooperation between NARC and cooperating units.

c. NARC has both a departmental and program-based organization. Is this a strength or a handicap in promoting multidisciplinary research?

CONSTRAINTS:

-- Generally overall research environment (in the country) is not conducive for science and research. It creates obstructions, humiliation, discouragement, deprivation, frustration and finally degeneration of bright brains.

-- Specifically, at PSI we lack research space/necessary facilities to work with plants.

RESOURCE NEEDS:

a. Funds: It is a multi-year planning. Budget will be developed once the multi-year research program is okayed.

b. Human resources: Manpower is the very heart of any operation. Well-trained, dedicated and productive staff can make all the differences. We need 25 trained specialized scientists with Ph.D. to implement the proposed research program and achieve desired objectives.

DR. N. I. HASHMI, WHEAT, BARLEY & TRITICALE, DATED FEBRUARY 25, 1988

RESEARCH MANAGEMENT: The wheat program research work at NARC is discussed and approved by the Cereals Technical Working Group and the NARC Research Committee. Whereas the coordinated program holds an Annual Program meeting each year to finalize the main thrusts for each of the eight cooperating units.

CONSTRAINTS:

The major constraints reducing the capacity of the program to address the issues are:

-- Backup of cytogenetics and quality laboratories is an absolute must.

-- Availability of reliable funds released timely will increase efficiency.

-- Mobility for on-farm work of testing varieties and development of package of production technology is crucial.

-- Trained manpower at Ph.D and M.Sc level in various disciplines is very important for providing leadership at all wheat research setups.

-- Agromet support service is lacking.

-- Greenhouse facilities for disease work and also for wide crosses program is needed.

DR. MOHAMMAD ASLAM, MAIZE, DATED FEBRUARY 25, 1988

RESEARCH MANAGEMENT: The program presently operates under the discipline and guidelines provided in:

i) Long term work plan.

ii) Annual operational plan.

The program activities are regularly presented and reviewed by Technical Working Group Committee. The annual program of work is presented in planning meeting of coordinated program where maize scientists from all provinces and cooperating units participate.

CONSTRAINTS:

-- Insufficient funds
-- Manpower inadequacy
-- Lack of incentives
-- Procedural difficulties

RECOMMENDED STRATEGY:

-- Adequate funds should be provided annually to run the priority projects smoothly.

-- Some of the staff members are under training abroad. An immediate need for additional staff at least one qualified agronomist and one breeder will solve the immediate needs of NARC Maize Research.

MR.ABDUL SHAKOOR, SORGHUM & MILLET, DATED FEBRUARY 25, 1988

RESEARCH MANAGEMENT: Efficient research management is of vital importance for the success of research and attainment of the set objectives. It involves making crucial decisions with regard to important issues such as research planning and organization; staff recruitment, guidance and motivation; and monitoring of research progress. As there are several levels of management starting with the program leader and ending with the top management of the research organization, the decision making process could be cumbersome with adverse effects on research activities. Simplification of the decision making process, efficient utilization of the available resources and creation of a congenial atmosphere that enables the research workers to do their best, are among the prominent features of efficient research management.

CONSTRAINTS:

a. Shortage of manpower (scientific and support)

b. Lack of interdisciplinary research.

c. Inadequate facilities (funds, vehicles) for on-farm research.

d. Lack of lab. equipments.

e. Lack of direct telephone facilities.

RESOURCE NEEDS:

1. Research Scientists (Plant breeding, physiology, pathology, entomology) and technicians.

2. Building: Only two rooms are assigned for the program at present with the increase of staff, there will be more need for office space. Also there is need for seed store, bird-proof cages, and glass house facilities for conducting research on drought and heat tolerance.

3. Equipments: Equipment such as seed drills, threshers, dryers, moisture testers and weighing balances are needed for the trials. In addition, seed cleaners, treaters and graders are needed for production of nucleous seeds of released varieties.

4. Mobility: In order to carry out an effective on-farm research program there is urgent need for adequate and reliable transportation. At present, the program has only one old car which is not working most of the time.

5. Operational Funds: Inadequate operational funds has been a constraint in research in the past. Provision of adequate funds for supplies, stationery, casual labor, POL, travel etc. is essential for doing effective research. Good coordination with the provinces requires frequent field visits, meetings, seminars, exchange of material and publications etc. and adequate funds are needed to cover these activities.

RECOMMENDED STRATEGY:

1. Special consideration should be given to provision of adequate resources (staff, physical facilities, equipment and operational funds) to the Sorghum & Millet program.

2. Reorganizing the role of qualified and dedicated staff in the success of the program, training and terms of employment and promotion of staff should receive due consideration.

3. Concerted effort is needed to simplify lines of communication within NARC/PARC to remove constraints with regard to timely release of funds.

4. Close linkages with other programs at NARC, in the provinces and at international institutes are essential for attaining the set objectives of the sorghum & millet program

MR. BANARAS BHATTI, FODDER, DATED FEBRUARY 25, 1988

RESEARCH MANAGEMENT: All provincial principal investigators of National Cooperative Fodder Research Program at different institutes deal their research problems with M (CS) through national coordinator of the project. Member (CS) also enjoys a key position in deciding policy matters and giving advice in research planning and in the implementation of the program.

The program leader with the cooperation of his research staff, prepares Annual Research Program, NARC Unit for Rabi and Kharif which is thoroughly discussed and vetted through Technical Working Group (TWG) and finally approved by a Research Committee for its operation.

The coordinator is the key person of a research program who should be technically competent, hard working and devoted to run the research program successfully but his dedication can never bring fruitful results to achieve the targetted goals of research and production until he enjoys the full cooperation and support from research staff, administration and finance authorities.

CONSTRAINTS:

-- Fodder crops are considered as major crops and not the priority crops. Financial resource allocation at federal and provincial levels for fodder crops research is inadequate.

-- Shortage of scientific staff and lack of provision of even short term foreign training to technical staff.

-- Lack of mobility and funds for conducting on-farm research.

-- Lack of coordination/linkage with international institutes and even with related disciplines (e.g. livestock) at NARC.

-- There is no private agency engaged in the production of quality seed.

-- Non-availability of regular journals/abstracts on fodder crops in the library.

-- Lack of scientific equipment for plant/proximate analysis.

RECOMMENDED STRATEGY:

-- Fodder crops be given due importance in our crop husbandry as to wheat, cotton and rice etc. and package of improved technology developed for increased production should be disseminated among farmers by the extension staff.

-- Establishment of Research Institute/Research Sections on fodder crops in each province is of prime importance for an efficient livestock production program/dairy industry in the country.

-- Strong linkages between fodder research in Pakistan and advanced institutions of the world like CIAT, CSIRO Australia, DSIR, New Zealand, ICRISAT, India, Universities of Florida, Georgia, Texas and Hawaii be immediately developed so as to undertake collaborative research on fodder crops.

-- Sound seed production program be developed for multiplication of prebasic seed of different fodder crops at Agricultural, Livestock Farms till it is taken up by the private sector or seed corporations.

-- Seed quality standards especially in hybrid crops be established so as to ensure supply of quality seed to the farmers by the private companies.

-- Sugar mills should establish livestock feed mills in their production zon so that mollases and wastes of the mills are used for livestock feeding in the mill area.

-- Integration of livestock and fodder production is a must for achieving the targets of milk and meat production in the country.

-- Due attention be given to the quality testing, preservation and conservat of fodder surpluses and development of varieties for sick soils.

-- Compulsorily recreational leave to program leaders for one month in a year be granted with the additional benefit of grooming/training of the younger scientists to share the responsibilities of program leaders.

-- Imparting of in-service training of 6-12 months of Fodder researchers and 3-4 weeks study visits for program leaders on yearly basis at the international centres of excellence, on top priority basis.

RESOURCE NEEDS:

-- Staff: (SSOs = 2, SOs = 4, ASOs = 2)

-- Budget:

Local Currency	=	Rs.16.50 million
F.E.C.	=	$ 0.62 million

-- Plant analysis laboratory/facility.

-- Office and Research equipment.

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DR. WAHEED AHMED, REPRODUCTIVE PHYSIOLOGY ETC. (ASI), DATED MARCH 01, 1988

4. RESEARCH MANAGEMENT:

Research management has key role to play in attainment of the objectives set for a research programme. It is required to help in planning, development and implementation of research projects, procurement of essentials like equipment and chemicals, provision of other requisite facilities and materials, etc. It also involves frequent exchange of views with the scientists working in the programme, in related disciplines, in provinces, and at the international level. Other desired attributes of research management are guidance and motivation, monitoring of progress, and organising seminars at national and international level in relevant disciplines. It is also involved in developmental and extension activities. The management can be expected to be efficient if it is least involved in unwieldy activities of too much office work, writing unnecessary and repetitive reports, and other such time-consuming activities. Provision of adequate office staff for additional activities will help ease the pressure, especially for as centralized a set up as ASI. Help and understanding from the top management and its support staff is rather a prerequisite to create a congenial atmosphere to derive best out of the programme research management and its research workers.

4.1 Constraints:

1. Shortage of well qualified scientific/ office support staff.
2. Transport facilities provided to ASI are not adequate.
3. Funds provided to run the institute are most inadequate.
4. Inadequate lab. equipment.
5. Lack of incentives and procedural difficulties.

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4.2 Recommended Strategy:

- In the absence of adequate re-[illegible], it becomes impossible to pursue the programme objectives. It is imperative that adequate resources in terms of operational funds, staff and equipment be provided. ASI has been rather neglected in this behalf.

- Proper incentive and promotions be provided to the Scientific Staff, as success of a research programme depends on their dedication. It is also important that personal grievances are timely removed.

- Lack of training may hamper research progress. Proper training be provided wherever needed. Presently, training in embryo transfer is very much required.

4.3 Resource Needs:

- A pick up be provided for efficient running of the Livestock Experiment Farm. At least another new vehicle must be provided to ASI, in lieu of an old one, especially in view of the fact that one ASI vehicle is involved in pick and drop duty.

- Proper physical facilities be developed at the new Livestock Experiment Farm, which are absolutely essential, such as equipping the milking [illegible] with milking machine and other relevant equipment, provision of automatic drinkers, etc.

- Qualified scientists in the field of Reproductive Physiology are required to run the research programme effectively.

- Equipment for L.T. lab. is urgently required to undertake work on cryopreservation, sexing and splitting of embryos, and also for poultry programme to establish a hatchery (incubator, electronic scale, etc.)

- Inadequacy of operational funds is a big constraint in research. Adequate funds are needed for proper implementation of research projects, and for organizing seminars, meetings, exchanging of materials and publications, etc. The budget of ASI needs to be doubled to meet all essential expenditure.

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DR. ASHIQ H. CHEEMA, ANIMAL HEALTH, DATED MARCH 01, 1988

RESEARCH MANAGEMENT: Research projects are first cleared by the technical working group and finally approved by the NARC Research Committee. A policy of participative supervision is being followed in this unit whereby the project leaders carry out their share of research work and provide practical guidance to junior researchers. The progress of research work is reviewed in formal meetings each month.

CONSTRAINTS:

1. There is no separate operational budget for the unit and the researchers do not know as to how much money would be available for their work and where it come from.

2. The work is being hampered due to the lack of suitable building space. Isolation facilities for virus lab. and infectuous diseases, post-mortem room and incinerator are urgently required.

3. There is no senior parasitologist and trained technicians for pathology and parasitology are needed.

4. The procedure for procurement of laboratory equipment and materials is inefficient and time consuming.

5. Important veterinary journals and books are not available. Long delays occur in getting the bibliography and reprints.

RECOMMENDED STRATEGY:

1. Separate operational budget should be earmarked for the Animal Health Unit.

2. Alterations should be made in the old livestock farm buildings to create virus isolation and infectuous diseases isolation facilities. Post-mortem room and incinerator should be provided in the new animal farm buildings.

3. A senior parasitologist and two technicians (one for pathology and one for parasitology) should be recruited immediately.

4. The procurement procedure should be streamlined to make it more efficient and responsive to the researcher's needs.

5. Professional journals and books should be subscribed. The time for receiving bibliographies and reprints should be in days and weeks and not in months.

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DR. AMANAT ALI, ANIMAL NUTRITION, DATED MARCH 01, 1988

RESEARCH MANAGEMENT: The program leaders are the persons who carry out the day to day management of all the activities of the project. They should be given the opportunities to interact and discuss their problems and issues with policy makers. The project leaders should be given proper respect, professional freedom and administrative/financial powers to plan and implement the approved programs so that the necessary progress is ensured.

CONSTRAINTS: The constraints in recruitment, incentives, trainings, awards, movement of vehicles, expenditure, procurement, power supply, experimental animals and sheds, apparatuses, chemicals, feed, ingredients, red tapeism. An environment of trust, confidence and security is necessary for efficient research and development work.

RECOMMENDED STRATEGY: Recommendations of program leader may be given due weightage in recruitment, career advancement, award of incentives to the staff. To facilitate expenditure, the budget break-up should be considered as a guide only. The reappropriation may be within the competency of the program leaders. Approval/sanction for any amount with the budgetary allocation may rest with the program leader. In the running of vehicles program leader be given powers keeping in view the nature of the program. Procurement procedures need radical change. The proposals made by the other program leaders in this regard are agreed.

RESOURCE NEEDS: Adequate staff with necessary operational funds is required to carry out the proposed activities.

Future needs: CSO = 1, PSO = 2, SSO = 4, SO = 8
ASO/Lab. Tech. = 3

DR. NASIM, FISHERIES, DATED MARCH 01, 1988

CONSTRAINTS:

-- Fisheries program falls at low priority

-- Shortage of trained manpower

-- No institute in the country offers exclusive degree level courses in fisheries.

-- Lack of a comprehensive aquaculture extension program.

-- Lack of infrastructural and/or inadequate institutional facilities to conduct production-oriented adaptive research in aquaculture.

-- Inadequate data base.

-- Inappropriate funding.

RESOURCE NEEDS:

1.	CSO = 1	Ph.D.	Fisheries and allied aquaculture.
2.	PSO = 1	Ph.D.	Fisheries and allied aquaculture.
3.	SSO = 5	Ph.D.	Fish breeding Fish diseases
4.	SO = 8	M.Sc.	Fish nutrition Fish genetics Shrimp culture
5.	ASO = 4	B.Sc.	Zoology - preferably fresh water biology.
6.	Field Staff = 10		Skilled/unskilled.

Pond & other facilities.

1.	Rearing ponds	=	30
2.	Concrete raceway-type tanks	=	10
3.	Fiber glass tanks	=	50
4.	Fiber glass troughs	=	20
5.	Aquaria	=	60

6. Fisheries Lab. (equipped for limnological nutritional, pathological breeding and genetic studies).

7. Water lab. (completely equipped).

8. Feed storage & preparation unit

9. Tube well ½ cusic capacity.

10. Pick up equipped with fish hauling tanks (for transportation)

Funds. Approximately 0.12 million/annum.

MR. M. A. NAQVI, SHEEP & WOOL, DATED MARCH 01, 1988

RESEARCH MANAGEMENT: Research management is virtually a full time job. It involves development of new projects alongwith budget preparation. Procureme of new research equipment and specially chemicals, is another important feature which is essential to bring/maintain the labs. to international standards. It also involves constant exchange of views/ideas/proposals with scientists working in the program/other related disciplines/provincial scientists/progressive farmers/international experts etc. The organization of national/international seminars in the discipline for the benefit of the scientists in the field is another desirable activity.

CONSTRAINTS:

-- Shortage of qualified scientists in the areas of sheep and wool production.

-- Shortage of laboratory equipment/chemicals and exotic sheep.

-- Non availability of vehicles at the Central Research Stations as well as outreach units.

-- Shortage of support staff.

-- Shortage of funds for the construction of sheep sheds at the cooperative units.

-- Library facilities are too inadequate in the field of sheep & wool.

-- The procurement procedures are cumbersome.

-- There is neither a Lab. Assistant nor Lab. Attendant.

-- Since donor agency is yet to be identified, no foreign exchange has been provided so far, hence matching local component is also not fully released

-- Scholarship facility for the project scientists is inadequate.

RECOMMENDED STRATEGY:

-- Vacant posts should be filled up in order to run the project smoothly and to achieve the goal.

-- The program leader should be authorised to make direct purchase upto Rs.25,000 to 30,000.

-- A vehicle should be allocated to NARC unit of the program immediately.

-- Adequate promotion/career advancement opportunities be provided to senior scientists.

-- In-service training facilities of 6-12 months duration at international centres of excellence every three years should be provided to scientists of this program.

RESOURCE NEEDS: The Govt. of Pakistan should be approached to allocate a higher percent of GNP to research than presently allocated.

DR. M. S. KHAN RANA, TRAINING INSTITUTE, DATED MARCH 08, 1988

CONSTRAINTS AND RESOURCE NEEDS:

a- Data-base computer information system should exist at the training institute for both management and coordination with extension staff.

b- Establishment of auto-tutorial laboratory.

c- Construction of additional lecture rooms, cafeteria, and more space would be needed.

d- Vehicle.

e- Complete wing of VIP rooms to accomodate national and international guest trainers.

RECOMMENDED STRATEGY:

Composition and size of training institute is not sufficient to meet its mandate. With the upgradation of this institute to academy we would certainly need more facilities in respect of space, staff. Six posts of BPS-17 under MART project were sanctioned but two officers were recruited. The appointment of these officers will facilitate the management in training programs and research activities at the centre.

RESOURCE NEEDS:

a- Additional funds may be allocated for the proper functioning of the institute.

b- Provision of better logistics for improving the work efficiency.

MALIK MUSHTAQ AHMED, PUBLICATION & S.I.U., DATED MARCH 08, 1988

RESEARCH MANAGEMENT: The major research management issue of the Directorate are as under:-

-- The shifting of CRISP staff/equipment from PARC headquarters to Information Directorate at NARC or a firm decision to keep them at PARC but administratively with the Director Scientific Information, NARC. Because of the placement of CRISP at PARC with Social Sciences Division, it is cut off from the mainstream information activity at NARC and is also devoid of expert technical guidance and management.

-- With the implementation of MART Project, thinking has developed with the higher management that there is likely to be some duplication in the functions of A.V. Unit and the Directorate of Scientific Information. This issue is being looked into and a proposal is being developed by the Director (Scientific Information & Publications) which will be implemented in near future, after approval of the competent authority.

CONSTRAINTS:

1. Lack of linkages with international agricultural databases to readily meet the information needs of the local scientists.

2. Lack of access to the fast growing technology for information storage, retrieval and dissemination.

RECOMMENDED STRATEGY:

The successful implementation of future programs suggested above would be instrumental in overcoming the constraint number one in providing access to the international sources of information in the developed world.

To overcome the 2nd constraint, the technical staff working with the Directorate of Scientific Information & Publications should be occasionally exposed to the new technologies through arranged visits/training to the selected international information centres preferably in USA, UK and Japan.

RESOURCE NEEDS:

-- Three computer terminals for NARC library with interfacing arrangements.
-- AGRICOLA on CD-ROM with disk drive.
-- AGRIS on CD-ROM.
-- Core Agricultural Journals (UMI, USA)
-- Expert Systems Retrieval (Foreign Expertise Required).
-- Dissertation Microfilms (UMI, USA).
-- Local Area network (LAN)
-- National Agricultural Database - 2 PS/2 computers.
-- Optical disk technology (foreign expertise required).
-- Graphic production software and projection hardware from computer to wall.
-- Compiographic composing equipment with two input terminals.
-- Laser printer.

MR. IKRAM SAEED, SOCIO-ECONOMICS, DATED MARCH 08, 1988

CONSTRAINTS:

1. Insufficient office accomodation.

2. Shortage of experienced and highly qualified manpower.

3. Procedural complexities and delayed recruitment system.

4. Inadequate computer facility.

5. Shortage of operating funds.

RESOURCE NEEDS:

Scientific Manpower. (CSO=1, PSO=2, SSO=6, SO=12)

Training Facilities. Long Term Training: Ph.D. = 4
Short " " =12

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CONSTRAINTS:

1. Shortage of trained and highly qualified manpower.

2. Inadequate office accomodation.

3. Insufficient number of micro-computers.

4. Non-availability of relevant research literature.