THE MART/AZR PROJECT

HIGH ELEVATION RESEARCH IN PAKISTAN

Pakistan Agricultural Research Council

ARID ZONE RESEARCH INSTITUTE

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This research report series is issued by the Management of Agricultural Research and Technology Project/Arid Zone Research Component (MART/AZR). This project is sponsored financially by the Mission to Pakistan of the United States Agency for International Development (USAID).

The project contract is implemented by the International Center for Agricultural Research in the Dry Areas (ICARDA) at the Pakistan Agricultural Research Council's Arid Zone Research Institute (AZRI).

This Institute has responsibility for undertaking dryland agricultural research in all provinces in Pakistan through its headquarters in Quetta, Baluchistan and its sub-stations at D.I. Khan (NWFP), Umerkot (Sind) and Bahawalpur (Punjab).

This series of research reports outlines the joint research findings of the MART/AZR Project and AZRI. It will encompass a broad range of subjects within the sphere of dryland agricultural research and is aimed at researchers, extension workers and agricultural policy-makers concerned with the development of the resource-poor, arid areas of West Asia and North Africa.

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HIGH ELEVATION RESEARCH IN PAKISTAN
THE MART/AZR PROJECT

ANNUAL REPORT 1990

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and

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(AZRI is supported by the USAID Mission to Pakistan under the Management of Agricultural Research and Technology (MART) Project, Arid Zone Research (AZR) component: Grant Number 391-0489-G-00-0501-00)

Table of Contents

List of Common Abbreviations

AZRI	Arid Zone Research Institute
BOSTID	Board of Science and Technology for International Development, National Academy of Sciences, Washington
CBWH	Catchment basin water harvesting
DM	Dry matter
FAO	Food and Agricultural Organization of the United Nations
FYM	Farm yard manure
GOB	Government of Balochistan
GOP	Government of Pakistan
ICARDA	International Center for Agricultural Research in the Dry Areas
MART	Management of Agricultural Research and Technology
MART/AZR	Management of Agricultural Research and Technology - Arid Zones Research (component)
PARC	Pakistani Agricultural Research Council
SAZDA	Sindh Arid Zones Development Authority
TDM	Total dry matter
UNDP	United Nations Development Program
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

1. The year 1990 was a transition period for ICARDA's technical assistance to AZRI, with the change-over from the first to the second phase of USAID support under the MART project. Phase I started in 1985 as a contract with ICARDA and Colorado State University and then from December 1, 1989 USAID extended its support to AZRI for a further 22 months by awarding a $1.5 million grant to ICARDA. Three new ICARDA advisors arrived between March and July 1990, the previous five advisors under phase I having left between September 1988 and May 1990. Phase II of the MART/AZR component aims to allow more time for the technologies developed during the first phase to be verified in on-farm studies. It will also allow more time for AZRI scientists to complete graduate degrees in the USA and return to strengthen the research capability of AZRI. In July 1990 the MART project was amended and now gives more emphasis to the involvement of agri-business in the activities of public sector research institutions. The experimental sites used by the MART/AZR Project in Balochistan Province of Pakistan are shown in Figure 1.

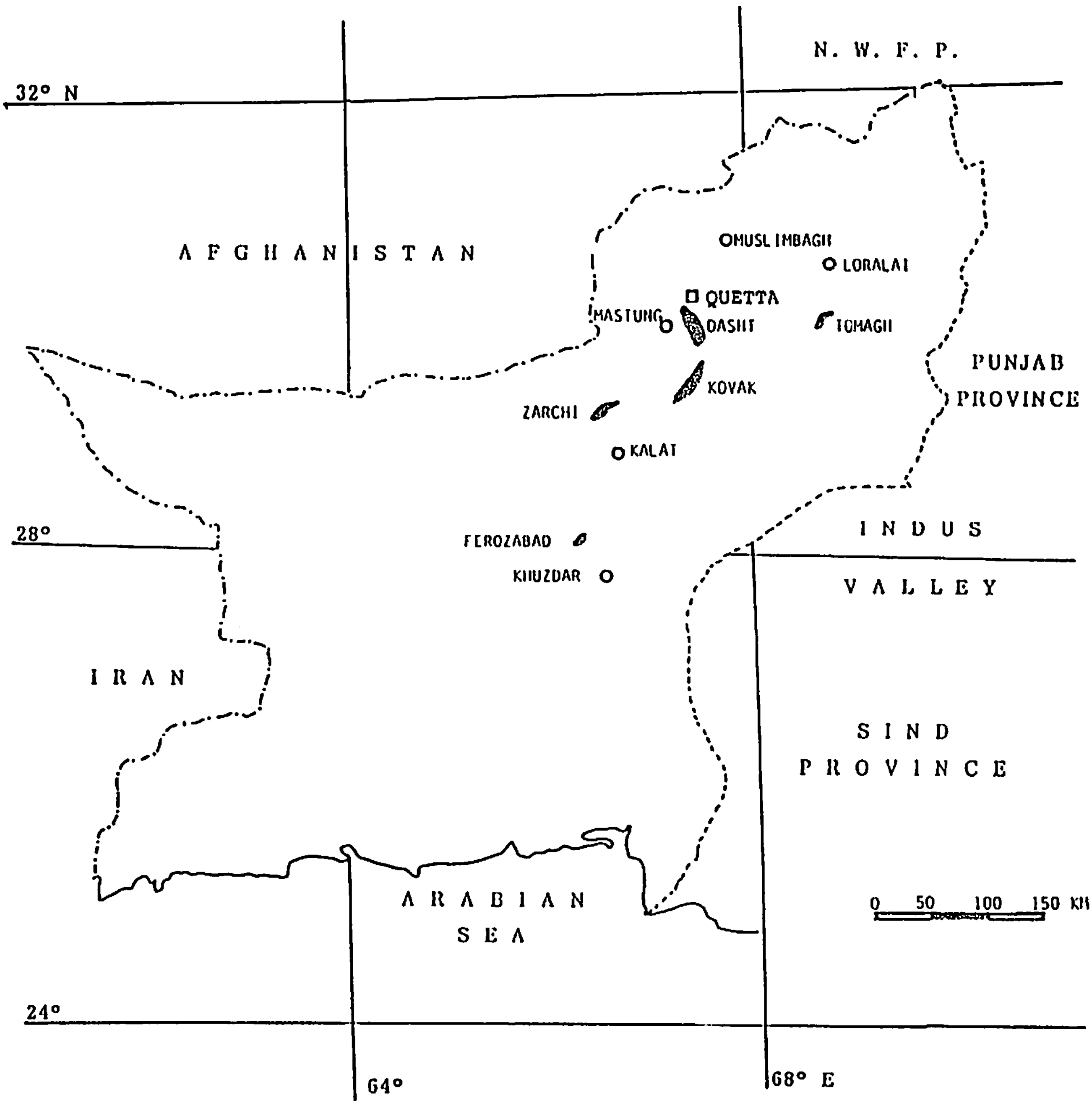
2. A study on seasonal changes in nutritive value of the range species at Tomagh and Zarchi, and the grazing behaviour of sheep and goats was completed as part of a PhD thesis. Forage quality decreased from spring to fall and contents of protein and phosphorus were usually insufficient for the animals needs. At Tomagh and Zarchi the stocking rates were 2.7 and 5-12 ha/small ruminant. Ranges at these sites could support sheep and goats provided appropriate stocking rates were used.

3. Fourwing saltbush (Atriplex canescens) fodder banks established 3.5 years previously yielded between 700 and 2200 kg aerial biomass/ha, which consisted of 49-61% wood. This shows the fuelwood potential of this species, and also its value as a reserve of livestock feed for deficit periods in winter and spring.

4. Fourwing saltbush supplemented with cottonseed cake maintained lambs for a 10 week period with no ill effects. In another trial lambs on a fourwing saltbush fodder bank made low but positive liveweight gains over a three month period.

5. Trials at Tomagh and Zarchi indicated how improving the level of nutrition of

FIGURE 1. MART/AZR PROJECT EXPERIMENTAL SITES IN BALUCHISTAN PROVINCE, PAKISTAN



ewes grazing degraded ranges resulted in higher ewe fertility, higher birth and weaning weights of lambs, and lower mortality of ewes and lambs.

6. A survey of yellow rust infestation in wheat crops during the 1989/90 season revealed that most farmers use well adapted local landraces, which satisfy local taste criteria and have good straw production. However, these landraces are susceptible to yellow rust (Puccinia striiformis) infections in wetter years. Straw is as valuable as grain in the absence of yellow rust and even more valuable when there is epidemic. The estimated losses due to yellow rust in 1989/90 in three representative districts of highland Balochistan were 123 and 77 Rs million for grain and straw, respectively. Although the prob-ability of an epidemic of yellow rust is only once every five to seven years it poses a serious production risk.

7. Balochistan, with 4.9 million people, has less than 5% of the population of Pakistan, but has 36% of the country's camels. They are widely used for diverse farming activities and for transport in the rural and urban areas. 136 camel owners were interviewed in highland Balochistan, and 57% said that they expected to continue using camels or oxen during the next ten years. 32% said they use tractors for field preparation, while another 35% said they would like to use them but could not afford to do so because tractor costs are much higher than camel costs. Due to tribal or communal land ownership, camel forage is almost free. In addition, the small landholding sizes influence the preference for camels over tractors.

8. A small ruminant marketing survey showed that the average price paid by consumers is Rs 716/hd, while producers get Rs 496/hd on average. The Rs 220 marketing margin represents 30.5% of the price paid by the consumer, which is then shared by the intermediaries in the marketing chain. The commission agents are often accused of taking advantage of the other intermediaries, or even of forcing down returns to producers. However, it is not generally appreciated that commission agents bargain on the basis of their knowledge of real market forces in Quetta and other major cities outside Balochistan. Most services provided by the intermediaries could be improved for the benefit of consumers and producers: the quantity of meat marketed could be greater, the quality could be more uniform, and some marketing costs could be decreased.

9. A whole farm planning model to assess sequential decision making in highland Balochistan under conditions of uncertainty is being developed. The model incorporates the following components: climate, annual crops, a perennial forage (Atriplex canescens-fourwing saltbush), range plants, livestock, and socio-economic constraints. Included in the model are: 1) highly uncertain and erratic climatic condit ons which determine crop and livestock production, 2) land tenure and social structure and 3) market price fluctuations. Applications of the model are numerous; however, the most logical ones are those that involve the evaluation of AZRI technologies applied to specific social organizations associated with land tenure.

10. Catchment basin water harvesting (CBWH) trials, started in 1986/87, went on with small changes into 1989/90. The catchments were set up by ploughing with a tractor-mounted mouldboard plough, then pulverising and levelling the soil with a heavy wooden plank. Once set up, catchments should remain effective for many years with only minor upkeep costs. The three treatments in 1989/90 were control, with the whole area cropped, a 1:1 catchment-to-crop area with the upper half a smoothed catchment, and a 2:1 catchment-to-crop area with the top two-thirds smoothed. Wheat, barley and woollypod vetch were grown. CBWH increased the TDM of all the crops, with the 2:1 treatment exceeding the 1:1, which surpassed the control. Grain yields were affected differently; the 1:1 surpassed the control for all three crops but the 2:1 plots of wheat and vetch did not exceed the control, and were poorer than 1:1 plots. Waterlogging lasted for slightly longer in the 2:1 than in the 1:1 and control; this affected grain production in the wheat and vetch more than in the barley, which was more tolerant of the temporary waterlogging. CBWH has a modest potential to increase yields and reduce risks of crop failure where there is erratic, low, variable rainfall. The waterlogging in the 2:1 treatment will be tackled in 1990/91.

11. Trials on woollypod vetch were conducted to measure both forage and seed yields from five seed rates - 30, 60, 90, 120 and 150 kg seed/ha - with and without inoculum, and with and without phosphate. The 30 and 60 kg/ha seed rates were best for seed production, and for forage production 60 kg/ha was best. Both seed and TDM yields declined at the higher seed rates. Inoculum increased yields significantly, but phosphate gave only small increases.

12. Factorial trials were laid down at Kolpur, Mastung and Miangundi to measure the effects of 10 t/ha of FYM, and fertilizers (40 kg N/ha and 60 kg P_2O_5/ha), on Pak 81 wheat and Arabi Abiad barley. Yields at Kolpur were higher because an appreciable amount of sailaba run-on water was received on the site. There, significant grain and TDM yield increases were obtained from both FYM and fertilizer application, while barley outyielded wheat by 51%. At the other two kushkaba sites yields were lower and significant responses fewer.

13. A fertilizer trial with four rates of nitrogen and four rates of phosphate was laid down as a 4 x 4 factorial with three replications. The rates were 0, 20, 40 and 80 kg N/ha applied as ammonium nitrate, and phosphate at 0, 30, 60 and 120 kg P_2O_5 /ha applied as triple superphosphate at planting. No significant response to either nitrogen or phosphate was obtained.

14. To find out if intercrops of cereals and vetch could increase production and make harvesting easier, intercropping trials have been conducted for some years. In 1989/90 the four treatments were: monocropped wheat, monocropped woollypod vetch, a single row of vetch sown between 2 rows of wheat and a single row of wheat sown between 2 rows of vetch. At the Kolpur sailaba site, intercropping reduced total grain yield compared with pure wheat, but having one row of wheat between two rows of vetch increased overall forage yields.

15. Research activities at AZRI continued to be severely handicapped by a shortage of well trained staff. Agricultural Economics, Agronomy and Germplasm were most affected. The Range/Livestock situation improved in 1990 with the return of the first AZRI scientist with a PhD from the US. At the end of 1990 there were eight vacancies in the scientific officer grades. Seven staff were on long-term training, six of them in the US and one in Australia.

Chapter 1

INTRODUCTION

The year 1990 was a period of transition for ICARDA's technical assistance to AZRI with the change-ove: from the first to the second phase of USAID support under the MART project. Phase I started in 1985 as a contract with ICARDA and Colorado State University and from December 1, 1989 USAID extended its support to AZRI for a further 22 months by awarding a $1.5 million grant to ICARDA. Three new ICARDA advisors arrived between March and July 1990, the previous five advisors under phase I having left between September 1988 and May 1990. Phase II of the MART/AZR component aims to allow more time for the technologies developed during the first phase to be verified in on-farm studies. It will also allow more time for AZRI scientists to complete graduate degrees in the USA and return to strengthen the research capability of AZRI. In July 1990 the MART project was amended and it now gives more emphasis to the involvement of agri-business in the activities of public sector research institutions.

Impressive changes have taken place at AZRI since 1985. During Phase I of MART/AZR, which can be designated the establishment phase of the Institute, a comprehensive research program was initiated and this resulted in the identification of several new technologies which will be further refined during Phase II in collaboration with farmers. A major training activity was also initiated and the benefits of this effort are now beginning to show with the return of the first AZRI scientist with a PhD from the US. AZRI also produced an impressive series of research reports and these will be continued with more emphasis being given to publishing in international refereed journals.

The 1990 Annual Report has five main chapters and each one summarises the most important research conducted during 1990. Most of the activities were started during phase I of MART/AZR. One of the main achievements of 1990 was to carry out a careful review of all the current research. This helped AZRI focus its future research more closely on those technologies that show the greatest chance of being adopted by farmers. This focusing in itself is an important aspect of any research institute's management. However, it is also necessary because the funding environment is becoming increasingly harsh. As a result of the review, some activities were terminated.

The second chapter outlines the aspects of the amended MART project that are relevant to AZRI, indicates how AZRI will respond to the amendment and presents AZRI activities in 1991 and beyond. Subsequent chapters report the activities of the five groups at AZRI: Range and Livestock, Agricultural Economics, Agronomy and Germplasm. The activities of the Extension group will be reported next year. The last chapter outlines staffing matters, and training and workshop activities.

Acknowledgements

Particular thanks are due to the Chairman of PARC, Dr C.M. Anwar Khan and the PARC Member Natural Resources, Mr Muhammad Rafiq, who both provided continuous support and encouragement to AZRI during 1990. Dr B. Roidar Khan, Director AZRI, deserves special mention as the key person who devotes endless effort to strengthening AZRI. His special efforts to help the three ICARDA advisors accomplish their respective tasks are much appreciated.

Thanks are also extended to the USAID Mission to Pakistan which has been supporting AZRI through the MART project since 1985, and in particular to Dr Curtis Nissly, always ready and willing to deal with requests from Quetta.

During 1990, ICARDA staff in the AZRI office had to become accustomed to working with the new advisors. This they did in a fine spirit of cooperation, and all continued to show a commendable degree of devotion to the project, especially Mr Pesi Amaria who is responsible for all financial matters concerning the project, and the day-to-day office management. It will be a pleasure to carry on working with them in 1991.

December 1990

Euan F. Thomson
ICARDA Team Leader

(Copies of this report are available from the AZRI address given on the cover).

Chapter 2

THE MART AMENDMENT AND AZRI IN 1991-92 AND BEYOND

This chapter outlines the goal, purpose and AZRI research areas indicated in the amended MART/AZR project document, and describes the major activities of AZRI in 1991-92 and possible developments after 1992.

The Amended MART/AZR Project

Project goal. The goal of the amended project is to:

- "improve the incomes of resource poor farmers, sustain an increase in food and fibre production, and conserve the natural resource base".

Project purpose. The purpose of the amended project is to:

1. "develop and disseminate improved technology and information through key research institutions", and
2. "foster a collaborative relationship whereby research institutes serve agri-business and farmers and use agri-business to disseminate marketable, improved technologies".

Thus, the main change in focus of the amended project is the inclusion of agri-business in the research process in such a way that public sector research institutions respond to the interests of agri-business, as well as to farmers and government agencies.

Research areas. During the amendment period, AZRI will conduct research in the following areas:

- improvement of livestock and rangeland management and rangeland rehabilitation,
- commercialization of improved germplasm of annual cereals and legumes, as well as range forages and shrubs,
- improvement of forage and dual-purpose crop yields by water harvesting techniques,
- evaluation of socio-economic aspects of sheep and goat production and

associated forage and dual-purpose crop production, and
- increasing the quality of wool and skins from sheep and goats.

Major AZRI research activities 1991-92. The three ICARDA advisors are supporting the following groups: Range and Livestock; Agricultural Economics; and Agronomy and Germplasm. Because of severe shortages of trained scientific staff at AZRI only top priority activities are being addressed.

The activities of the **Range and Livestock** groups include:

a. Examining the options for the rehabilitation of rangeland vegetation. This includes testing the introduction of perennial grasses, forage legumes and forage shrubs into range plant communities. In conjunction with these introductions, land treatment practices are being tested which improve the capture and retention of precipitation in the root zone. These practices, which include ripping, contouring, micro-catchment formation and other types of run-off capture technology, are intended to improve plant establishment and productivity.

b. Studies on the effects of an improved quantity and quality of feed on sheep and goat productivity throughout the annual production cycle. The relationships between different and variable sources of feed and key animal production parameters will be determined.

c. Use of feeding strategies to supplement animals grazing range, including use of introduced forage plants and urea treated straw, and alternative breeding schedules.

d. Relationships of livestock diseases and parasites with fertility, mortality and productivity of grazing animals.

The activities of the **Agronomy and Germplasm** groups include:

a. Examination of water harvesting strategies. This includes the study of contour bund design, spillways in bunds, field levelling with locally available technology, surface sealing methods, etc.

b. Possibilities of using spillover water which could not infiltrate in the cropped area of water catchment fields, for establishing range forage shrub reserves. This will include the possibility of dual-purpose forage and fuelwood species.

c. Determining whether alternative agronomic strategies in combination with improved methods of water harvesting can be profitable, and can assist in ensuring a better, and more stable return to investment by farmers than the current uncertain, subsistence system. Emphasis is being placed on producing more abundant and alternative sources of animal feed for sale or for direct consumption in mixed livestock/crop enterprises.

d. The Range/Livestock group is being helped to examine ways in which micro-catchment runoff systems promote better and more sustained productivity of introduced range forage shrubs.

e. Studies on the screening, selection and introduction of improved germplasm of forage and dual purpose crop species (barley, vetch, lentil, wheat etc.) are being continued.

f. Contacts are being made with commercial seed producers to assess the possibilities for developing a private sector seed industry, including the propagation and sale of forage shrubs.

The activities of the **Agricultural Economics** group continue to suffer from an acute shortage of trained scientific staff and therefore its activities are being limited to the following:

a. Profitability and compatibility of AZRI-generated technologies with current agricultural systems. This requires assessment of both individual technologies as well as enterprise option studies in order to maximize farm/flock production efficiency and minimize the longterm risk experienced by communities supported largely by agriculture.

b. The social and economic acceptability of different water harvesting strategies is being assessed.

c. Socio-economic constraints to livestock production in the upland areas of Pakistan such as livestock marketing. This research will include a survey of current meat, wool and skin marketing practices and recommendations will be made to improve the returns to producers from the sale of better quality livestock products.

d. A model is being developed to: measure the impact of AZRI technologies on farm productivity and income stability; to assist with the identification of research areas; and to help prioritize research activities according to the potential benefit to farm productivity and income stability.

Public sector incentives for responsiveness to the private sector. The MART amendment elaborates on four types of incentives for further development under the project: a) credit for establishing agri-business linkages as part of the annual evaluation process - this complements and supports a continuing effort to improve personnel management in research institutions and increases the merit factor in all promotion considerations; b) allocation of research grants that involve a direct agri-business linkage; c) honoraria equivalent to 10 percent of salary; and d) contacts and opportunities. AZRI staff will be encouraged to respond to these incentives.

AZRI in 1991-92 and Beyond

Considerable efforts are being made to continue support to AZRI until the mid-1990s by which time AZRI should have a cadre of up to 10 PhDs and close links with GOB departments and agri-business, thus helping it to finance much of its research from non-federal sources. Some of the important tasks in 1991-92 and beyond are outlined in the following section.

Graduate degree training. The first AZRI scientist to complete a PhD program in the US funded, by MART returned to AZRI in October 1990 and another six staff will complete their degrees between 1992 and 1995. Two more scientists will start PhD programs in 1991 and another three are preparing to do so using other funding. Therefore AZRI will not have a full complement of staff with PhDs until 1995-96. The three ICARDA advisors are assisting with the formulation of research programs of the AZRI staff about to start PhD programs and are making every effort to ensure that candidates choose a research topic relevant to problems in Balochistan. Efforts are made to ensure that during their PhD program at least two periods each of six months are spent at AZRI conducting part of their thesis research.

Short-term training. AZRI and GOB staff will be encouraged to attend short-term training at ICARDA or elsewhere when a genuine need has been identified and a well qualified candidate is available.

English language training and scientific writing. English language training is continuing, with particular emphasis being given to AZRI staff preparing for overseas graduate degree training. Assistance will also be given with the writing and editing of research reports and scientific papers. Staff from provincial departments are invited to attend these courses.

Linkages with provincial departments. Particular efforts will be made in 1991 to strengthen linkages between AZRI and the GOB Departments of Agriculture, Extension, Livestock and Forestry. These efforts will initially involve training of GOB staff by hands-on participation in current projects of AZRI for periods between three months and one year. Field days at on-farm trial locations will also be organized. However, it is planned to hold discussions between AZRI and GOB that develop a more structured mechanism of collaboration where some of AZRI's research has been defined by GOB. In effect this will mean that AZRI will conduct research for the GOB on a contract "the-user-pays" basis. By winning such contracts AZRI will generate funding for research operating and equipment costs with the fixed costs such as salaries, utilities, etc., being paid from its PARC budget allocation.

Public research institutes and agri-business linkages. AZRI is responding to the concepts presented in the MART amendment by planning a one-day seminar in May 1991 involving agri-business, GOB officials and farmers. The seminar aims to:

- establish linkages between AZRI and agri-business,
- present technologies developed at AZRI which have a potential market in Balochistan and other provinces, and
- identify potential problems facing agribusiness that could be studied by AZRI on a contract basis.

In this regard seed, skin and wool merchants, as well as the animal health industry will be contacted. It will be necessary to approach these businesses in Punjab and Sindh as Balochistan only has an embryonic agri-business sector. Indeed, pastoralists and farmers without irrigated crops in Balochistan are largely subsistence oriented. Thus, the incentives to agri-business to establish branches are small and this may limit their interest in the province until researchers have shown that farmers are adopting some of the new technologies developed during the last five years at AZRI. The expertise in the newly established PARC Agri-Business Cell, which is an initiative taken under MART, will be called upon to assist AZRI in its efforts to create a partnership with agri-business.

More farmer participation in the research process. So far little mention has been made of the farmer, the ultimate beneficiary of researcher's efforts. Many diagnostic surveys have been conducted since 1985 to identify the difficulties facing farmers. However, their involvement in technology testing needs to be increased so that researchers can judge whether the new technologies will be adopted and if not, for what reasons. Field days will be organized to allow interaction between farmers from different areas and with GOB officials.

As well as increasing the involvement of farmers in the research process, a seminar will be held in early 1991 at which farmers will be invited to express their views concerning the technologies that AZRI has tested to date, and also indicate those subjects which they feel deserve the attention of researchers. These subjects may or may not concur with the objectives of AZRI. However, they will indicate whether AZRI needs to revise its research objectives during the coming two years.

Prioritized project planning and budgeting. In early 1991 AZRI staff will complete budget forms for research projects they wish to continue or start later in 1991. The total budget needed to conduct the new and ongoing research will be developed and priorities assigned to each project. The proposed research will be reviewed and revised in-house and approved proposals will be presented at the annual planning meeting in May 1991. The priorities of the other partners in research - farmers, agri-business and GOB departments - which will be identified during the seminars, will be taken into account and where possible incorporated into the research plans for the next year.

USAID/MART support. Phase II of MART/AZR is fully funded until September 30, 1991 and efforts are being made to extend this funding until December 31, 1992. A research proposal requesting funding beyond September 1991 will be submitted to USAID Islamabad in early 1991.

BOSTID grants. The amended MART project includes BOSTID grants covering three years and each grant provides $50,000 to $100,000 towards research operating costs and equipment, salaries for temporary staff, short-term training, consultants, workshops, seminars and publications. It is hoped that AZRI will be awarded these grants which start in June 1991. Three research proposals were submitted to PARC and BOSTID in October 1990 on the following subjects:

- the response of range vegetation to weather and management variables in highland Balochistan,
- can the productivity of sheep be increased by better management of indigenous breeds in highland Balochistan? and
- use of water-harvesting to enhance crop production in arid and semi-arid areas of highland Balochistan.

World Bank. The World Bank is negotiating a second credit to Pakistan (under the Agriculture Research II project, ARP II) for a seven year period starting in April 1991. Components of this credit will be provided to both AZRI, through PARC, and the GOB. The AZRI allocation is for equipment, staff training and research operating funds and it is complementary to funds provided by MART and ICARDA. A small allocation is provided for similar items at the AZRI sub-station Umerkot.

AZRI and the ICARDA Highland Region Network. As USAID support to AZRI is phased out during the next few years it will be necessary for ICARDA to change its relationship with AZRI from being a supporter to becoming a partner institution. It is suggested that the modus operandi for this new relationship would be to incorporate AZRI into a research and information network covering the highland regions of Pakistan, Iran, and Turkey in the first instance. These regions come under ICARDA's Highlands Region which is administered by a Regional Coordinator based in Ankara.

Chapter 3

RANGE AND LIVESTOCK GROUP
(ICARDA Advisor: E.F. Thomson)

Introduction

Balochistan is the largest province of Pakistan covering over 34 million ha and about 93% of this area is classified as rangeland. However, nearly 10 million ha are considered to be unproductive, 12 million ha provide very poor grazing and nearly two million ha are undergrazed because of inaccessibility and a lack of water. Thus fair-to-good grazing covers only about 10 million ha (FAO, 1983). With an estimated small ruminant population of 12.8 million head in 1986, a seven-fold increase since 1955 (GOP, 1986), the pressure on the 22 million ha of poor-to-good grazing is about 0.6 small ruminant per ha averaged over the year.

The advanced degradation of most of the ranges in Balochistan is evidence that this grazing pressure is not sustainable. To better understand why range degradation has reached such an advanced stage it is necessary to examine the seasonal variations in grazing pressure. The grazing pressure in spring and summer on the Balochistan rangeland is undoubtedly well above one small ruminant per ha whereas in winter and autumn, when many of the animals go to the Indus Valley, it is probably well below this level. This system has been followed for centuries as flock owners realised how to obtain the best nutrition for their animals. Today, with a worsening imbalance between the demands of the increasing numbers of livestock and the ability of the range vegetation to support them, alternative feed resources need to be found for spring and summer so that grazing pressure on the range plants is reduced at the time when they need to recover and set seed.

On the other hand, the female animals are pregnant and lactating during winter and spring, the period of the year when the range is least able to support them because their nutrient demands are the highest. If they are well nourished during this period higher fertility results, and the increased milk production of the female helps the young to be healthy and fast growing.

Strategic feeding systems need to be designed for this period to supplement the depleted ranges, thus ensuring maximum offtake in a sustainable manner.

Research is being conducted at AZRI on range ecology, nutrition and improvement, on novel fodder reserves, on strategic feeding systems, and on improving the quality of animal products. These aspects of the research conducted in 1988/89 and 1989/90 are outlined in the following chapter.

Range Ecology, Nutrition and Improvement

An essential step in the overall research strategy on range and livestock at AZRI is to define the seasonal productivity of range species, the relative nutritive value and animal preference of the different species, and estimate sustainable stocking rates. Such research is outlined in the following section.

Nutritive value of range vegetation and grazing behaviour of sheep and goats (A. W. Jasra, M. Islam and J. Afzal): a study was conducted at Zarchi and Tomagh in 1988 and 1989 to assess the nutritional status of sheep and goats grazing two contrasting rangeland types which had been protected since 1987 (Wahid, 1990). These types are the shrub ranges dominated by A. maritima and H. griffithii at Zarchi and the grass range at Tomagh dominated by C. shoenanthus[1] and C. aucheri. Seasonal above ground biomass production and variability in the quality of grasses, forbs and shrubs was determined at four phenological growth stages namely, vegetative (April), bloom (May/June), maturity (July) and dormancy (September/October). In addition, the relative palatability index of major plant species and preference of sheep and goats was also determined in the first season using microhistological methods and in the second season using animal observations.

The content of phosphorus across the different plant species was similar (Figure 2). At both sites spring range species had the highest quality and thereafter quality decreased; there were also differences in the quality of the various groups of species. Grasses were somewhat lower in protein content and

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[1]This may be a more precise name than C. jwarancusa and needs verifying.

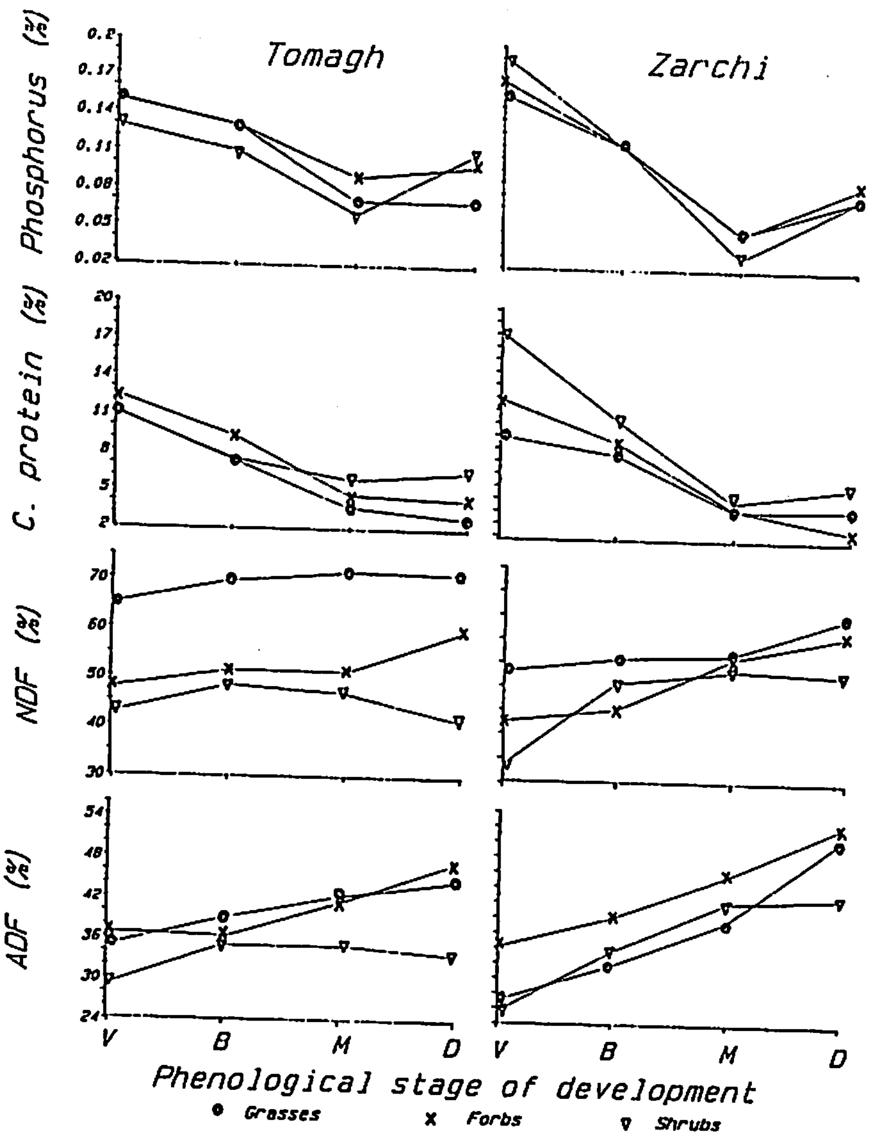

Figure 2. Changes in the phosphorus, crude protein, neutral detergent fibre (NDF), acid detergent fibre (ADF) of grasses forbs and shrubs at Tomagh and Zarchi at four phenological stages in 1988. (V = vegetative, B = bloom, M = maturity and D = dormancy).

higher in neutral detergent fibre content than forbs and shrubs. The content of acid detergent fibre increased as plants matured and there were no consistent differences between the grasses, forbs and shrubs.

From March to October sheep and goat diets differed in their botanical composition at the two sites. Grasses remained a major component of their diets at Tomagh throughout the grazing season, but they consumed a higher percentage of shrubs with the passage of time while grazing at Zarchi. Across both grazing seasons the diets of both animal species were deficient in protein and phosphorus.

The study made it possible to estimate annual stocking rates using the amount of standing crop of those plants eaten by the animals, animal requirements and the nutrient content of the plant species (Table 1). In most years, if grazing pressure is moderate, plant quantity should not limit animal production, particularly at Tomagh. However, these values should be used with *caution* since the estimates are calculated using US breeds of small ruminants which generally have a higher mass than those in Balochistan. The values in Table 1 would therefore tend to be overestimates. They do indicate, however, the large difference in the potential carrying capacity of the Zarchi and Tomagh ranges. Even the values for the Tomagh type range, which probably have the highest carrying capacities in Balochistan, indicate that for sustainable production the area per small ruminant may need to be 2-3 hectare which is more

Table 1. Forage yields (kg DM/ha) averaged over four phenological growth stages, and estimated annual stocking rates[1] (ha/sheep or goat) at Tomagh and Zarchi in 1988 and 1989.

Site	Year	Grasses	Forbs	Shrubs	Totals	Stocking rate
Tomagh	1988	299	5	63	366	2.7
	1989	337	5	48	390	2.7
Zarchi	1988	<1	7	78	85	12.0
	1989	2	7	198	207	4.8

[1]Assuming 50% utilization of total DM produced.

than double the estimate for Balochistan. It is therefore not surprising that the ranges in Balochistan are so degraded.

The lignin ratio technique was also assessed as a method to determine daily dry matter intake and apparent digestibility of range plants ingested by animals. Highly variable digestion coefficients of lignin were obtained when using sheep and goat rumen liquors, with sometimes as much as 50% of the lignin in plant samples being digested. Conversely, negative lignin digestion coefficients in the range -1.0 to -103.0% were also found. Lignin biodegradation and/or complexing during in vitro digestion invalidated its use as an internal marker in the studies at Tomagh and Zarchi.

Jasra (1990) draws the following conclusions from his study:

1. Even though inter- and intra-seasonal variations in rainfall result in large fluctuations in vegetation levels on the rangelands of Balochistan, plant quantity should not limit sheep and goat production at the two sites if grazing pressure is properly adjusted. Stocking rates suggested in this study can serve as a guide for sustainable grazing management strategies.
2. Retrogression of climax plant communities to disclimax types is widespread in Tomagh. Palatable perennial grasses, such as C. aucheri, have been almost completely replaced by perennial species of low palatability such as C. shoenanthus. A rapid establishment of the latter species on a wide scale has brought about a large decline in the plant species diversity. It is therefore critical to direct future research towards the establishment of more desirable plant communities.
3. Energy deficiency, based on in vitro digestibility of the plant material, may not be a constraint to better animal production on grass dominated ranges like Tomagh. However, on shrub ranges like those at Zarchi, severe energy deficiency may threaten sheep and goat survival.
4. Sheep and goats grazing these two types of rangelands may experience phosphorus deficiencies for most parts of the year. However, this conclusion needs to be verified further since it is based on levels recommended by the National Academy of Science for sheep and goats in the US.
5. In areas like Tomagh, protein deficiencies would limit animal productivity after late spring. Protein supplementation, in combination with phosphorus, would be necessary to sustain animals during most of the year.

6. At Tomagh, sheep and goats are forced to graze on unpalatable perennial grasses which limits their dry matter intake. Riparian zones (dried stream beds) are a good source of green and palatable plants for animals throughout the year. However, these areas are limited in extent.
7. At Zarchi management should be directed towards expanding *Convolvulus leiocalycinus*, a palatable browse species which is equally liked by both sheep and goats. Information is required about its germination rate, seed production, growth pattern and growth parameters for successful propagation.

Acknowledgement. The research reported in this section was largely taken verbatim from the doctoral thesis of Abdul Wahid Jasra who returned to AZRI in October 1990 after completing his PhD at Oregon State University. He is the first AZRI scientist to complete a PhD with support from the MART project.

Cool and warm season perennial exotic grasses (G. Akbar): one commonly recommended strategy to increase the productivity of degraded ranges is to reseed with exotic grass species. AZRI has been testing since 1986 a number of commercially available exotic cool and warm season perennial grass species imported from the US. At the end of 1988 after a year when rainfall was particularly low, few of the entries sown one year earlier were still alive. Two of these, *Elymus junceus* (steppe ryegrass) and *Oryzopsis hymenoids* (desert ricegrass) showed considerable promise. Other species showing some tolerance to drought included pubescent wheatgrass (*Agropyron trichophorum*), intermediate wheatgrass (*A. intermedium*), thickspice wheatgrass (*A. dasystachyum*) and weeping lovegrass (*Eragrostis curvula*).

The research continued in 1989 with eleven exotic species of cool and warm season grasses being sown in February under rainfed conditions at Mastung and Tomagh. A completely randomized design was used with three replications. Seed of each species was sown in 7.5 m^2 plots, each having 7 rows of 5 m length with 25 cm between rows. At both locations dry matter yields of each species were measured in November 1989 before the onset of winter and then in June 1990, the summer season.

The dry matter yields of the grasses are shown in Table 2. At both sampling dates at Mastung *A. elongatum* was showing considerable promise, closely

Table 2. Forage yield (kg DM/ha) of exotic grass species at Mastung and Tomagh on two sampling dates.

Grass species (1 = warm season) (2 = cool season)	Mastung		Tomagh	
	Nov 89	June 90	Nov 89	June 90
Agropyron smithii(2)	79.0^{c}[1]	275.7^{bc}	56.6^{bc}	99.9^{ab}
A. *dasystachyum*(2)	46.7^{cd}	66.9^{cd}	67.8^{bc}	84.5^{b}
A. *elongatum*(2)	189.0^{a}	816.7^{a}	78.8^{bc}	109.5^{ab}
A. *trichophorum*(2)	138.7^{ab}	416.9^{b}	186.1^{ab}	42.4^{b}
A. *desertorum*(2)	34.9^{cd}	124.6^{cd}	36.9^{c}	26.5^{b}
Sporobolus airoides(2)	15.5^{d}	32.3^{d}	42.3^{bc}	39.7^{b}
Dactylis glomerata(2)	39.5^{cd}	120.3^{cd}	159.7^{abc}	93.4^{b}
E. *junceus*(2)	36.4^{cd}	47.9^{cd}	69.1^{bc}	49.0^{b}
E. *lehmanniana*(1)	-	-	3.00^{c}	40.6^{b}
E. *curvula*(1)	86.7^{bc}	133.0^{cd}	242.4^{a}	194.5^{a}
O. *hymenoides*(2)	1.6^{d}	17.2^{d}	32.1^{c}	55.7^{b}

[1]Values in the same column with different superscripts are significantly different ($P<0.05$).

followed by A. *trichophorum*. At Tomagh, A. *elongatum* and A. *trichophorum* were also quite productive but E. *curvula* showed the highest yield at both the first and second sampling dates. The superiority of E. *curvula* at Tomagh is largely related to the summer rainfall received at that site.

Sampling of the grasses will continue into 1991 to establish the persistency of the different species. Seed of other species from both New Zealand and the US has also been obtained for sowing during 1990/91.

Range herbarium (G. Akbar): in addition to research, efforts are under way to collect and identify specimens of range flora. Some 132 plant specimens collected during various AZRI range surveys have been sent to the University of Balochistan and the National Herbarium at PARC Islamabad, for identification and archiving.

Forage shrub and grass nursery (G. Akbar): nurseries of forage shrubs are maintained at Quetta, Zarchi and Tomagh, with most emphasis being given to raising fourwing saltbush (*Atriplex canescens*) seedlings for use in research studies and distribution among farmers. In addition other forage species such as A. nummularia, A. lentiformis, A. halimus, Caragana ambigua, Robinia pseudoacacia, Eurotia lanata and Prunus padus are also being raised at the AZRI nursery. Recently seeds of Quetta ash (Fraxinus xanthoxyloides), Dozakh (Gladitschia tricanthos) and Robinia pseudoacacia have been procured from the Pakistan Forest Institute, Peshawar for sowing at Quetta. A bedded nursery is also being maintained at Quetta in which a number of cool and warm season grasses and legumes are raised to provide seed for future studies.

Collaboration with the Provincial Forestry Department: at the request of the Balochistan Forest Department assistance is being provided in the design and implementation of various studies. The Department is studying different aspects of watershed and range improvement and its research division has recently laid out at Wahari, Loralai District, a detailed study on different water catchment systems. About 2500 seedlings of fourwing saltbush were also provided by AZRI. The Department has also kindly allocated to AZRI about 20 ha in Karkhassa State Forest, adjacent to AZRI station, for range research.

Fodder Banks Using Fourwing Saltbush (Atriplex canescens)

Fourwing saltbush is a promising forage shrub possessing cold, salt and drought tolerance and high nutritive value. For these reasons AZRI has been conducting research on this valuable shrub for several years. The research includes both the management and feeding value aspects of the species.

Establishment of fodder banks of fourwing saltbush (G. Akbar): one-year-old fourwing saltbush seedlings were planted at Zarchi, Quetta and Tomagh in February 1988 to establish fodder banks. There are 4444 plants per ha (1.5 x 1.5 m spacing) in unreplicated, fenced plots. The planting at the three sites differed as follows:

- **Zarchi**: seedlings were planted on slightly sloping land just above an earthen bund which is the traditional 'sailaba' water harvesting technique in Balochistan. Only one watering was applied at the time of planting.
- **Quetta**: seedlings were planted on relatively gravelly soil and irrigated once every two months for just one year.
- **Tomagh**: seedlings were planted on terraced land just after some winter

rains and then watered once a month for four months.

During August 1990 when the plants were almost 3.5 years old data were collected using destructive sampling. A diagonal transect was stretched between opposite corners of the plots and alternate plants coming in contact with the line were measured for their crown diameter and plant height. After recording these observations, the plants were cut to ground level and the leaves, twigs and stems separated, weighed and dried. The results were averaged across the plants sampled and converted to a hectare basis by multiplying by 4444.

Plants at Tomagh were taller, wider and more productive than at the other two locations since the rainfall there is higher and fairly well distributed between winter and summer (Table 3). The poor growth and productivity at Quetta is largely a result of the poor gravelly soils. Noteworthy is the proportion of woody material which ranged from 49 to 61% of the total aaerial biomass. This is an indication of the fuelwood potential of this species. These fodder banks will serve as valuable material for future studies on topics such as the grazing management of fourwing saltbush and regeneration potential after harvesting excess woody growth.

Table 3. Plant height (cm), crown diameter (cm) and aerial biomass production[1] (kg DM/ha) of fourwing saltbush at three different locations in highland Balochistan.

Location	Plant height	Crown diameter	Leaves and twigs	Wood	Total aerial biomass
Zarchi	71.8	94.6	1802.6	1718.7	3521.3
Quetta	73.2	107.0	1008.3	1563.4	2571.9
Tomagh	86.8	136.8	3347.8	4471.6	7818.8

[1]The values represent production after the plants had been growing for about 3.5 years. Since there is an unknown amount of leaf drop from the plants, it is not possible to estimate the annual leaf production by dividing by 3.5. In the case of wood and twigs this is possible because there are no losses of these components.

Micro-catchment water harvesting techniques and survival, growth and biomass production of fourwing saltbush under rainfed conditions (G. Akbar): during October 1989 a replicated study was initiated at Mastung, Tomagh and Zarchi to compare the performance of fourwing saltbush under four different micro-basin water harvesting techniques: V-shaped basins, saucer-shaped basins, contour furrows and ripped lines. Twenty-four ten-month old seedlings were planted in the plots of each treatment and there were four replicates. Preliminary observations revealed 97% survival in the V-shaped treatment and 90, 82 and 65% for saucer-shaped, contour furrows and ripped lines, respectively. Yields and growth rates under these treatments will be reported next year.

Feed value of fourwing saltbush (Atiq-ur-Rehman and S. Rafique): a study into the nutritive value of fourwing saltbush for growing lambs was conducted at AZRI in the summer 1989. Twenty-four Harnai lambs were divided into three groups and each group fed daily 4 kg of one of the following three rations (proportions of ingredients are given in brackets): wheat straw and lucerne hay (24:76), fourwing saltbush and cottonseed cake (71:29), and wheat straw and cottonseed cake (59:41). Liveweights were measured over eight weeks.

Dry matter intake and crude protein digestibility did not differ between the three rations (Table 4). However, the dry matter, acid detergent fibre and

Table 4. Daily dry matter intakes per lamb (g) and digestibility (%) of four rations offered to lambs.

	WS+LH[1]	FWSB+CSC	WS+CSC	SED[2]
Dry matter intake (g)	449	472	458	--
Digestibility (%):				
- dry matter	57.9[a3]	41.3[b]	57.0[a]	3.1
- crude protein	70.3	70.8	71.1	1.7
- acid detergent fibre	50.6[a]	13.2[b]	45.2[a]	3.9
- neutral detergent fibre	49.3[a]	21.6[b]	49.2[a]	4.0

[1]WS+LH = wheat straw + lucerne hay; FWSB+CSC = fourwing saltbush + cottonseed cake; WS+CSC = wheat straw + cottonseed cake.
[2]Standard error of difference.
[3]Values in the same row with different superscripts differ significantly ($P<0.05$)

neutral detergent fibre digestibilities of the ration containing fourwing saltbush were lower than the other two rations.

The study revealed that lambs can at least be maintained on a ration containing 71% saltbush (Figure 3). Noteworthy, however, were the positive gains of the lambs on the wheat straw/cottonseed cake ration as compared with the zero gains of lambs fed the wheat straw/lucerne hay ration which had the same apparent digestibilities. This indicates how measuring digestibility and intake alone may not be sufficient for identifying differences in the nutritive value of low quality rations supplemented with protein. In future it will be important to measure the relative rumen degradability of proteins and rumen ammonia concentration to understand more clearly the reasons for differences in the nutritive value of different rations.
(This trial was reported as MART/AZR Research Report No 58, and has also been accepted for publication in the Asian-Australasian Journal of Animal Science).

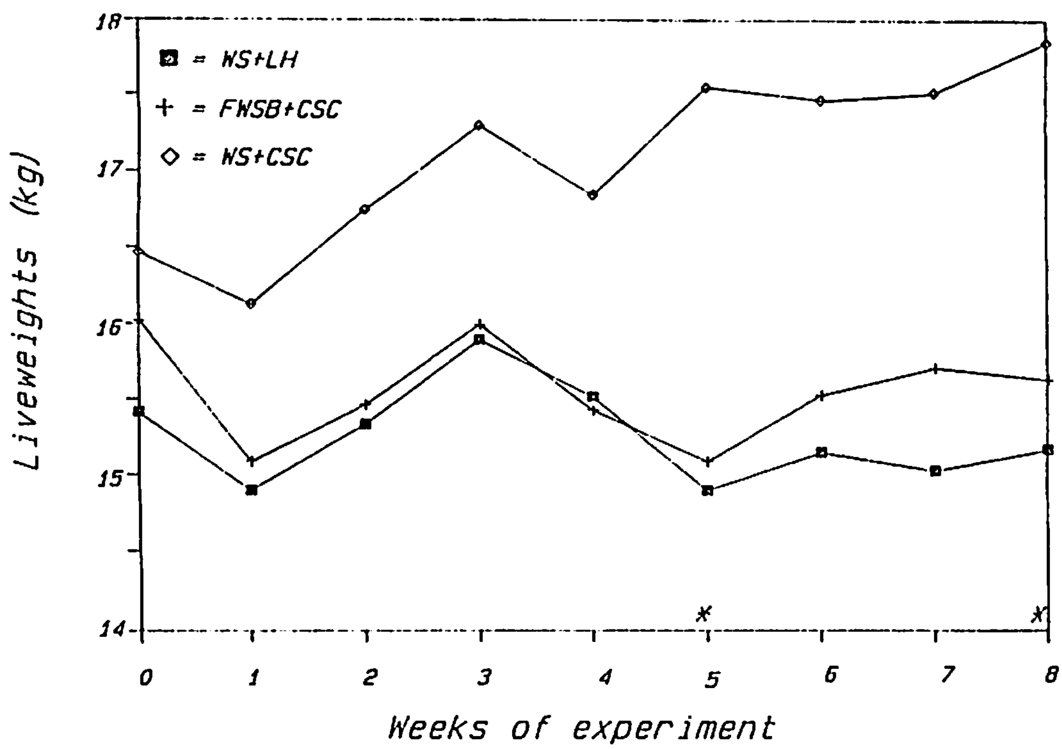

Figure 3. Liveweights of Harnai lambs fed one of three different rations (WS+LH = wheat straw and lucerne hay, FWSB+CSC = fourwing saltbush plus cottonseed cake, and WS+CSC = wheat straw plus cottonseed cake). [= significant difference between treatments, P<0.05].*

Fourwing saltbush as a winter maintenance forage for lambs (Atiq-ur-Rehman and S. Rafique): a study was conducted at Tomagh in the winter of 1988/89 which compared the liveweight changes of Harnai lambs grazing fourwing saltbush alone, range alone or range grazing with either 100 g barley grain per lamb each day or 100 g lucerne hay per lamb each day. There were four lambs in each group and the study lasted 10 weeks.

The lamb liveweights are shown in Figure 4. The lambs grazing native range and fourwing saltbush alone increased slightly in liveweight during the study period. In contrast, lambs grazing range and supplemented with energy from barley or protein from lucerne hay gained liveweight faster. The study revealed that lambs can at least be maintained for a 10 week period in winter on fourwing saltbush grazing alone.

(This research was presented in MART/AZR Research Report No 37 and also published in the Asian-Australasian Journal of Animal Science (1990) 3: 85-89.

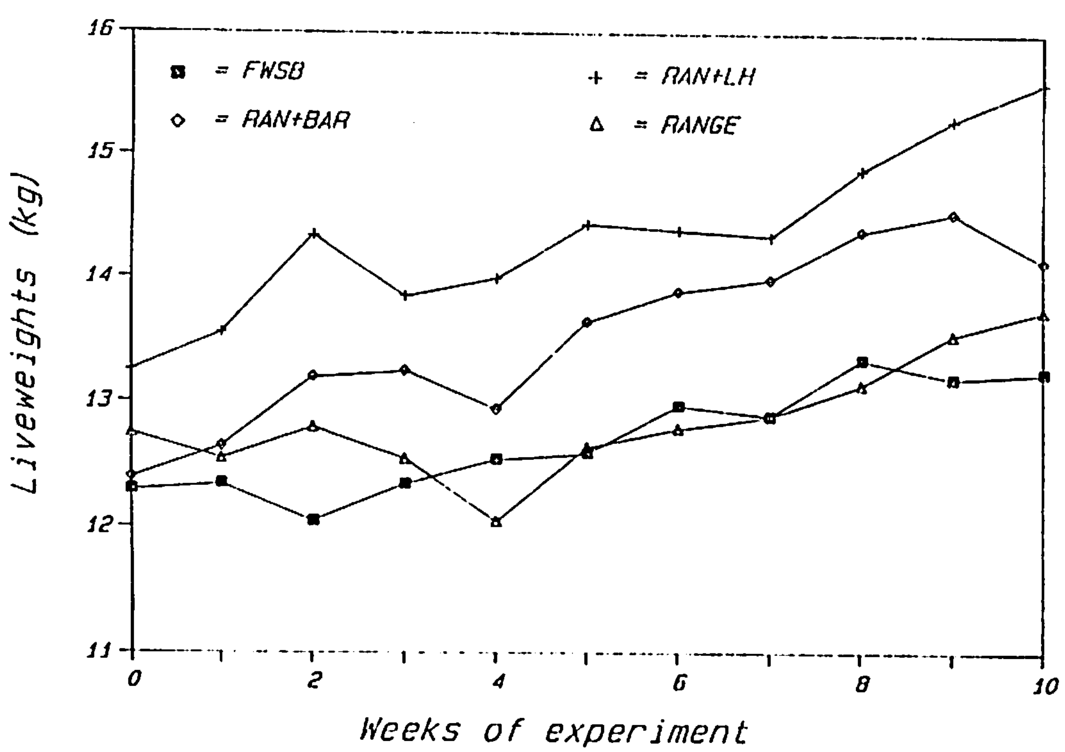

Figure 4. Liveweights of Harnai lambs on four different maintenance regimes. (FWSB = fourwing saltbush grazing alone, RANGE = range grazing alone, RAN+BAR = range grazing plus barley grain, and RAN+LH = range grazing plus lucerne hay).

Strategic Feeding Systems

Researchers face the dilemma that successful attempts to find additional feed resources could result in a further increase in animal numbers. There are at least two reasons for this: one is that farmers like to keep a large number of animals for security and status reasons, another is that fewer animals would die during periods of drought when range vegetation is scarce. This dilemma must be kept in mind when conducting research on additional feed resources for provision at strategic times during the overall breeding cycle such as the peri-breeding phase, late pregnancy and early lactation. Farmers will need to be educated that strategically timed supplemental feeding systems increase offtake from individual females making it is less necessary to increase numbers of animals.

A further aim of the research on strategic feeding systems is to define the genetic potential of breeds when applying good management and nutrition. Once the biological relationships are known it will be possible to define optimal levels of inputs for different price environments. Information to achieve these two aims is being collected in the supplementation studies conducted at Tomagh and Zarchi and reported below.

Supplementary feeding, fertility and productivity of ewes, and growth rate and mortality of lambs at Tomagh and Zarchi (1988/89) (S. Rafique, M. Munir, M.I. Sultani, and Atiq-ur-Rehman): a study was conducted to measure the effects of two levels of supplementation on fertility and productivity of ewes grazing the two contrasting range types at Tomagh and Zarchi. It started in October 1988, corresponding to the pre-breeding period, and continued until May 1989. At each location there were two groups offered either 250 (low) or 500 (high) g/ewe each day of supplements containing equal proportions of cottonseed cake and barley grain. All ewes were taken to graze the ranges each day. There were 80 Harnai ewes and 82 Balochi ewes in each group at Tomagh and Zarchi, respectively. Lambing took place in April and May 1989 and weaning was carried out 90 days after lambing. Data on conception and lambing rate, fortnightly liveweights of ewes and lambs, birth and weaning weights of lambs, and ewe and lamb mortality, were recorded.

At Tomagh the lambing rate was only 8%. The factors causing this could have been an out-break of pleuro-pneumonia in the region in November 1988 which may have contributed to the 30% abortion rate. The pleuro-pneumonia outbreak occurred even though the ewes had been vaccinated against this disease in late October. Ewes also experienced severe nutritional stress and lost weight in November 1988 following the scheduled termination of supplementation during mid-pregnancy. This stress might also have contributed to the severity of the pleuro-pneumonia and the incidence of abortions.

Conception and lambing rates at Zarchi were doubled and mortality reduced to a third by increasing the level of supplementation (Table 5). The low lambing rates were partly related to the purchase of 17 breeding ewes from the Balochistan Livestock Departments' Usta Mohammad Farm, none of which lambed. Excluding these ewes increases lambing rate to 33 and 69% for the low and high groups, respectively. Additional factors contributing to the low lambing rates were an unintentionally high ewe-to-ram ratio, because of one dominant ram, and a rather short 40 day breeding period which was intended to concentrate lambing into a few weeks.

Table 5. Percentage conception, lambing and mortality rates of ewes grazing native rangeland at Zarchi and supplemented at two levels (1988/89).

Feeding level	Conception rate (%)	Lambing rate (%)	Mortality rate (%)
Low	22.5[a1]	22.5[a]	12.5[a]
High	52.4	52.4	4.8

[1]Values in the same column differ significantly ($P<0.05$).

There were no differences in lamb birth weights at Zarchi. However, the lambs from well fed ewes had higher weaning weights (Table 6) and these ewes maintained higher liveweights than the ewes fed at the low level (Figure 5). Both groups of ewes recovered well during early lactation which coincided with the spring period of range plant regrowth.
(The 1988/89 Zarchi study was presented in MART/AZR Research Report No 59).

Table 6. Birth and weaning weights of lambs from ewes grazing native rangeland and supplemented at two levels at Zarchi (1988/89).

Feeding level	Birth weight (kg)	Weaning weight (kg)
Low	3.4±0.51[1]	12.6±2.22[a2]
High	3.2±0.65	14.8±2.65

[1]Standard error of mean.
[2]Values in the same column differ significantly (P<0.05).

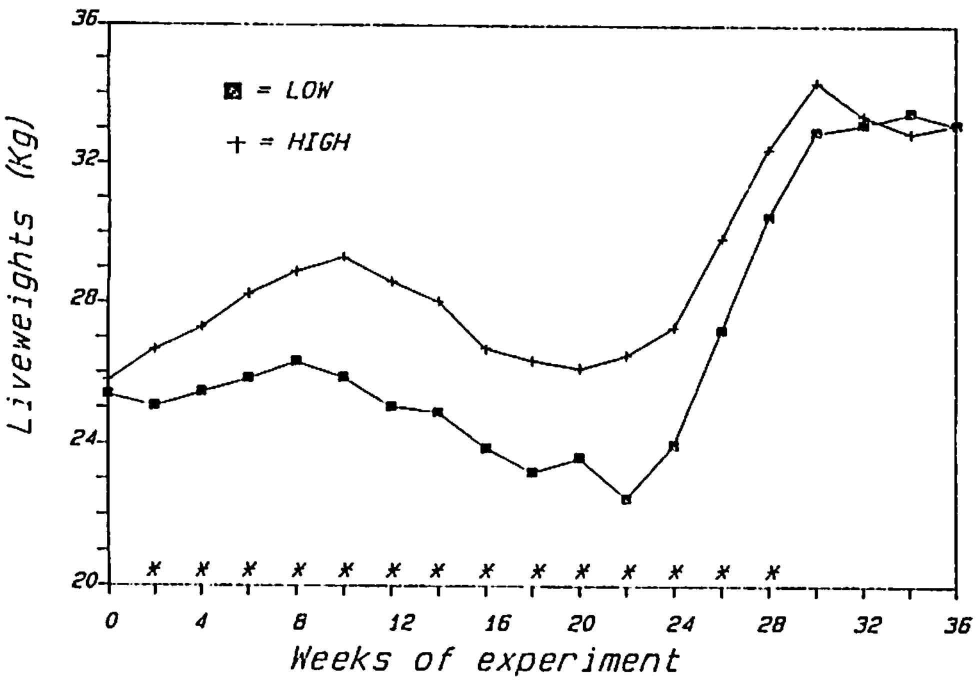

Figure 5. Liveweights of Balochi ewes grazing the native rangeland of Zarchi and supplemented at a low and a high level, starting mid-October 1988. [x = significant differences between treatments, P<0.05.

Performance of Harnai and Balochi ewes under different feeding levels during breeding, pregnancy and lactation (1989/90) (Atiq-Rehman, S. Rafique and M. Munir): a study was conducted at Tomagh and Zarchi between October 1989 and April 1990 to monitor the effect of improved nutritional management on productivity of ewes during the breeding, late pregnancy and early lactation periods when the availability of forage from the native ranges is very poor. At Tomagh and Zarchi 48 Harnai and Balochi ewes, respectively, were allocated at random to three treatment groups in a completely randomized design. The three feeding systems studied were:-

- Extensive feeding (EF): range grazing alone,
- Semi-intensive feeding (SIF): range grazing and low supplementation, and
- Intensive feeding (IF): no range grazing and high supplementation.

At Tomagh the low and high levels of supplementation were 625 and 1250 g/ewe each day, respectively, and at Zarchi 625 and 1875 g/ewe each day, respectively. The ration, which was group fed, contained 50% lucerne hay, 25% cottonseed cake, 15% wheat straw and 10% wheat bran. The crude protein and TDN contents were 12% and 54%, respectively. Salt was available in pens. Feeding started in early October 1989 at both locations. All ewes were vaccinated against enterotoxaemia and anthrax and drenched with nilverm (levamisol hydrochloride) to control internal parasites. Lambing took place mostly in March, 1990 and the lambs were weaned at three months of age. Ewes and lambs were weighed once every 14 days and just after lambing and at weaning.

A 100% conception rate was observed in ewes in all the three treatments at Tomagh whereas at Zarchi an improvement in both conception and lambing rate resulted from intensifying the feeding system (Table 7). Lambing rate compared favourably with the 60-70% found in surveys (Nagy et. al., 1989). Significant treatment differences in ewe liveweight at lambing were observed at Tomagh (Table 7) and ewe mortality was reduced by feeding more supplements. At Zarchi ewe mortality rates were less clearly related to feeding system.

Birth weights of lambs increased as the feeding system of ewes improved and indicated how poor nutritional status of ewes during pregnancy results in lower lamb birth weights (Table 8). Weaning weights of lambs from IF ewes were higher as compared with lambs from SIF and EF ewes which were similar. The

Table 7. Reproductive performance and mortality of ewes supplemented at three different levels at Tomagh and Zarchi (1989/90). (Harnai and Balochi breeds of sheep were used at Tomagh and Zarchi, respectively.)

Feeding system	Conception rate (%)		Lambing rate(%)		Ewe weight post lambing (kg)		Ewe mortality (%)	
	Tomagh	Zarchi	Tomagh	Zarchi	Tomagh	Zarchi	Tomagh	Zarchi
EF[1]	100.0	75.0	93.8	75.0	27.3^{a2}	-	6.3	0.0
SIF	100.0	87.5	100.0	87.5	34.0^{b}	-	0.0	6.3
IF	100.0	93.8	100.0	93.8	38.5^{c}	-	0.0	0.0

[1]EF = extensive feeding (range only); SIF = semi-intensive feeding; IF = intensive feeding.
[2]Values in the same column with different superscripts differ significantly (P<0.05).

Table 8. Performance of lambs from ewes supplemented at three different levels at Tomagh and Zarchi in spring 1990. (Harnai and Balochi breeds of sheep were used at Tomagh and Zarchi, respectively.)

Feeding system	Birth weight (kg)		Weaning weight (kg)		Mortality until weaning (%)	
	Tomagh	Zarchi	Tomagh	Zarchi	Tomagh	Zarchi
EF	2.8^{a1}	3.0^{a}	10.7^{a}	15.6^{a}	20.0	16.7^{a}
SIF	3.5^{b}	3.1^{b}	11.5^{a}	16.9^{a}	0.0	0.0^{b}
IF	3.8^{b}	3.8^{b}	13.5^{b}	19.2^{b}	12.5	0.0^{b}

[1]Values in the same column with different superscripts differ significantly (P<0.05).

lower birth weights of lambs from EF ewes resulted in higher mortality as compared with lambs from IF ewes.

The fortnightly liveweights of ewes during the experiment are shown in Figures 6 and 7. At both locations the feeding system had the expected effect

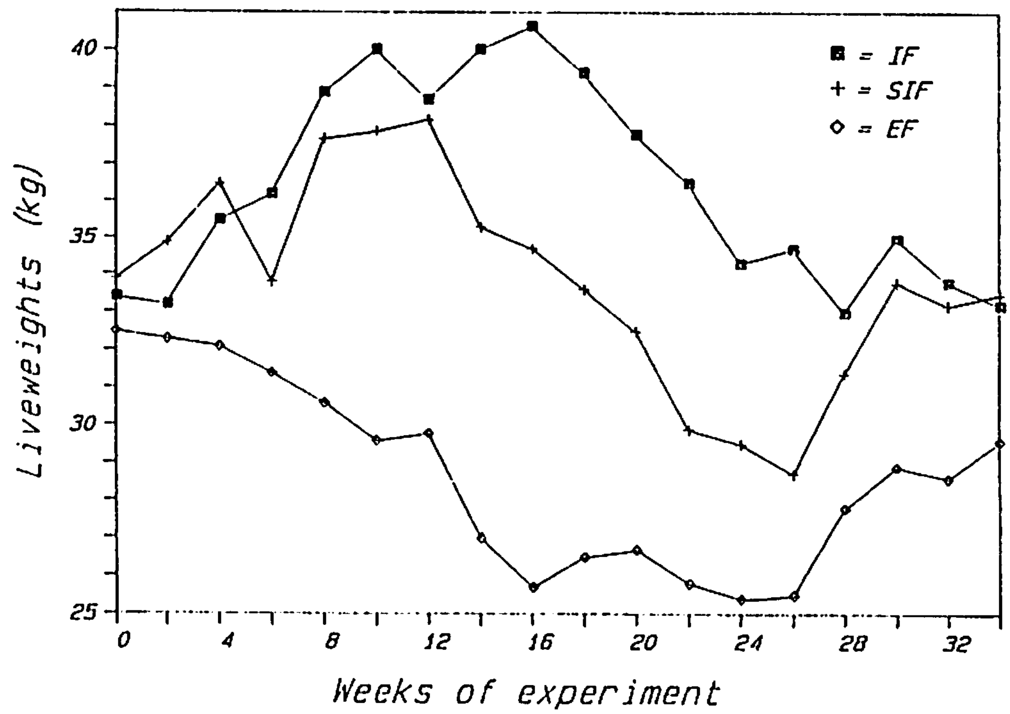

Figure 6. Liveweights of Harnai ewes maintained under three different feeding systems at Tomagh, starting in mid-October 1989. (EF = extensive feeding, SIF = semi-intensive feeding, and IF = intensive feeding).

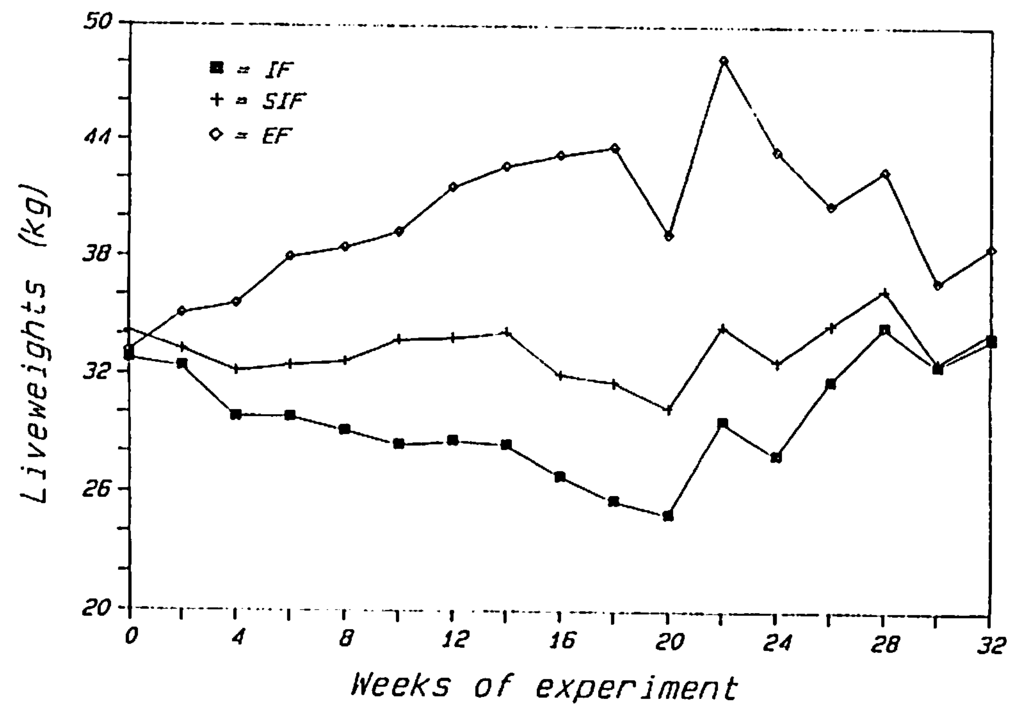

Figure 7. Liveweights of Balochi ewes maintained under three different feeding systems at Zarchi, starting in mid-October 1989. (EF = extensive feeding, SIF = semi-intensive feeding, and IF = intensive feeding).

on the liveweights of ewes and the differences between treatments were usually statistically significant. These results will be subjected to more detailed analysis to adjust all data to a common day of lambing. This will make it possible to interpret the results with more precision.

The study demonstrated the benefits from better nutritional and health management of ewes during the most critical periods of the reproductive cycle. The advantages of these management practices on range productivity and the cost-benefit ratio of these different feeding systems need to be evaluated.

Improving the Quality of Animal Products

Another step in the overall strategy to increase offtake without increasing animal numbers would be a higher market price for a better quality product. This provides a link with the livestock and meat marketing study reported in Chapter 4. To improve the quality of their lambs and kids farmers would need to improve nutrition and health of these animals. AZRI is studying ways to produce extra feed for livestock, such as from fourwing saltbush and woollypod vetch. Here there is a link with the activities of the Agronomy and Germplasm groups outlined in Chapters 5 and 6, respectively. The results of a study into the performance of lambs grazing vetches and barleys are reported in the following section.

Woollypod vetch and barley grazing for lamb fattening (S. Rafique, A. Ali, S. Ahmed, B.R. Khan, M. Munir and Atiq-ur-Rehman): a study was conducted at AZRI in the spring 1989 to compare the growth rate of lambs grazing woollypod vetches (Vicia villosa ssp. dasycarpa) and barleys at three stages of plant maturity, and to observe whether there were palatability differences between the species. There were two accessions of woollypod vetch - accession 683 from Syria, and Gilgit from Pakistan - and three barleys - the local landrace, the Syrian landrace Arabi Abiad, and Frontier 87, a selection from ICARDA released in Pakistan. Twenty Balochi lambs were divided into five groups and groups were allocated at random to the five treatments. Each group grazed one of the five pastures which had each been divided into three areas. The first, second and third areas were grazed consecutively at the pre-flowering, flowering and seed-hardening stages of plant maturity. The lambs grazed for a total of 44 and 49 days on Acc 683 and Gilgit, respectively, distributed almost equally across the three stages of maturity. They grazed the Arabi Abiad and Frontier 87 for a total of 27 and 28 days, respectively, and the local barley for only 12 days in total. To estimate dry matter yields, pastures in each plot were sampled before grazing started. Daily dry matter intake was estimated as: (total dry matter available per plot)/(number of lambs x days per plot).

The dry matter production of Gilgit was somewhat higher than Acc 683 at all stages of plant maturity and the vetches yielded more than the three barleys (Table 9). Arabi Abiad and Frontier 87 barleys produced similar yields which were higher than local barley except at the seed-hardening stage. Daily intakes were similar across the five species at the pre-flowering stage but at the flowering stage Arabi Abiad had the highest intake and local barley the lowest (Table 10). At the seed-hardening stage Acc 683 had a similar intake to Gilgit and Arabi Abiad but lower than Frontier 87 and the local barley.

Table 9. Dry matter production (kg DM/ha) of five different forage species harvested at three stages of maturity at Quetta (1989).

	Pre-flowering	Flowering	Seed hardening
Woollypod vetch, Acc 683	1529[b1]	2604[ab]	2656[ab]
Woollypod vetch, Acc Gilgit	2147[a]	3340[a]	3318[a]
Barley, var. Arabi Abiad	1280[b]	2302[b]	1956[bc]
Barley (Frontier'87)	1198[b]	2007[b]	1844[c]
Barley (Local)	733[c]	993[c]	1638[c]
SED[2]	140	318	249

[1]Values in the same column with different superscripts differ significantly ($P<0.05$).
[2]Standard error of difference.

The daily gains in liveweight are difficult to interpret since the grazing period at each stage of maturity, particularly in the case of the barleys, was often too short to remove the confounding effects of gut-fill changes. However, the results do indicate that there were probably no differences between the vetches (Table 11). When the gains are averaged over the entire grazing period lambs grazing Arabi Abiad barley had the highest gains followed by Acc 683, Gilgit and Frontier 87, and the local barley supported only poor rates of gain.

Table 10. Daily intake (g) of dry matter by sheep grazing five forage species at three stages of maturity (1989).

	Pre-flowering	Flowering	Seed hardening
Woollypod vetch, Acc 683	265	437^{b1}	353^{b}
Woollypod vetch, Acc Gilgit	336	426^{b}	439^{ab}
Barley, var. Arabi Abiad	288	687^{a}	459^{ab}
Barley (Frontier'87)	241	512^{b}	558^{a}
Barley (Local)	250	308^{c}	491^{a}
SED[2]	32.1	35.7	41.1

[1]Values in the same column with different superscripts differ significantly (P0<.05).
[2]Standard error of difference.

Table 11. Daily liveweight gains (g) of lambs grazing five forage species at three stages of maturity (1989). (Grazing days are shown in parentheses.)

	Pre-flowering	Flowering	Seed hardening	Overall
Woollypod vetch, Acc 683	7^{a1}(13)	133^{b}(14)	62^{b}(17)	65^{b} (44)
Woollypod vetch, Acc Gilgit	10^{a}(14)	95^{bc}(17)	129^{b}(18)	82^{ab}(49)
Barley, var. Arabi Abiad	5^{a}(10)	267^{a}(7)	103^{b}(10)	113^{a} (27)
Barley (Frontier'87)	46^{a}(11)	103^{bc}(9)	177^{ab}(8)	106^{ab}(28)
Barley (Local)	-150^{b}(5)	-6^{c}(5)	317^{a}(2)	13^{c} (12)
SED[2]	39.9	37.0	53.2	15.6

[1]Values in the same column with different superscripts differ significantly (P<0.05).
[2]Standard error of difference.

This preliminary study indicates that there are no palatability problems with the two woollypod vetches and that daily gains of lambs grazing them, Arabi Abiad and Frontier 87 are reasonable but probably below the genetic potential of the breed. A more comprehensive grazing trial is needed to determine the true potential of these different species for lamb fattening purposes.

Future Research

Jasra (1990) stated that "today, rangelands in Balochistan are almost completely devastated by overgrazing, however many opportunities for improved range management exist if scientifically based management techniques can be implemented". The problem is the implementation of these techniques and it is now time to make a determined effort at AZRI to find solutions to the problem. One proposal still at the discussion stage is to implement sustainable range management strategies by working closely with tribal leaders who still exercise a degree of control over a region where the ranges are still in reasonable condition. Efforts in this direction will be initiated in 1991.

The benefits of protecting ranges from grazing are sometimes dramatic, as is the case at Tomagh where perennial grasses predominate. On other range types the benefits are almost absent, as is the case at Zarchi where shrubs dominate the range flora. Considerable thought will have to be given to the continuation of the range studies at these two sites since they have been protected for several years, especially at Tomagh, and are therefore unrepresentative of the unprotected ranges of Balochistan. This is an obstacle to the transfer of the findings from these research areas to the open ranges. It will instead be more appropriate to work closely with farmers.

The research on perennial grass species will continue in 1990/91 but the results have been somewhat disappointing and it is questionable how much longer such research on exotic species should be continued, particularly when operating budgets are so limited. Another reason for questioning this research is the feasibility of reseeding as a technology to rehabilitate degraded rangelands. The costs of reseeding, the vast areas that need to be rehabilitated, and the difficulties of ensuring that the reseeded areas are managed in a sustainable manner, are other reasons for curtailing such research. An alternative strategy that is gaining favour at AZRI is to use native species to reseed areas where the rainfall conditions allow higher levels of range plant production and where the tribal system is still sufficiently effective to promote sustainable management of the ranges.

Research on fourwing saltbush will be given particular attention in the future by the Range/Livestock group at AZRI. The research will have two main directions, one fundamental and one adaptive. The fundamental research will investigate such aspects as methods of breaking seed dormancy, propagation from cuttings, pruning as a method to harvest fuelwood and its effects on plant regrowth, different defoliation strategies using sheep and goats, and feeding systems that maximise the benefits from fodder banks. A wider range of fourwing saltbush species will also be investigated. The information generated will be valuable for developing the range component of the AZRI modelling effort outlined in Chapter 4. The adaptive research will be conducted in on-farm trials with full participation of farmers who will be encouraged to give their views of the technology at all times of the evaluation stage. It is also proposed to plant fourwing saltbush in the spillover zone below the cropped areas of the water harvesting studies (see Chapter 5).

A gradual shift of the livestock research towards more careful definition of biological relationships will be initiated in 1991. For example, body condition scoring is being assessed as a potentially more accurate predictor of the nutritional status of ewes than liveweight. If it is found to be useful, then it should be possible to quantify the feeding of female animals more accurately so that their productive potential is reached. Another research proposal is to study the fertility of ewes as affected by breeding season. If ewes are found to be fertile from August to January then there is the possibility that farmers could choose a date of lambing to exploit seasonal fluctuations in livestock prices being monitored by the Agricultural Economics group. The results from such research will make it possible to interpret more easily research findings on fertility and small ruminant productivity and provide basic data on livestock productivity for the AZRI model.

The initiation of the possible future research directions outlined above will depend on the availability of well trained staff and an adequate operational budget.

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Chapter 4

AGRICULTURAL ECONOMICS GROUP

(ICARDA Advisor: A. Rodriguez)

Introduction

In the second phase of the MART/AZR project the Agricultural Economics (AE) group will devote more time to the analysis and interpretation of socio-economic information and technical data from the Agronomy, Germplasm, Range and Livestock groups rather than gathering more descriptive information (see ICARDA, 1990 for detailed scope of activities in the first phase). The transition to a more analytical phase must be timely and multi-disciplinary to assure continuity of the research projects in AZRI, synthesizing the information acquired and proceeding to in-depth analysis of the production and marketing constraints of the representative farming systems in highland Balochistan.

This chapter has been divided in five sections. The first one presents results from the 1990 wheat disease survey. This study is an example of the "eventual" research that can emerge from the AZRI research efforts supported by the AE group. The second section presents the 1989 camel agricultural utilization survey results and the third section presents a study on marketing of small ruminants. These two studies are of diagnostic character and are more representative of the first phase of the MART/AZR project; nevertheless, they serve as baselines for analysis and interpretation of socio-economic aspects of farming and marketing systems. The fourth section, the AZRI modelling effort, presents the outline of the whole farm model. In the fifth section, a series of activities for future research are mentioned. They emphasize the need to develop linkages with the emerging private sector of Balochistan which will assist in the identification of bottlenecks in production and marketing of AZRI commodities, and in suggesting alternative solutions to these bottlenecks. In addition, the viewpoints of pastoralists are also of major concern to the AE group.

Wheat Disease Survey

(Sarfraz Ahmad, G. Farid Sabir, B. Roidar Khan and M. Panah).

In the highlands of Balochistan wheat is the main dual purpose cereal crop cultivated under rainfed and irrigated conditions. The available local wheat landraces are well adapted to the harsh, arid environment, where the annual rainfall averages 250 mm. and shows great variability. They also satisfy the local taste criteria and have a high straw yield which is very important for livestock feeding. However, they are highly susceptible to yellow rust (Puccinia striiformis) attacks. The high humidity which occurs in wetter years results in outbreaks of epidemic proportions, which cause great revenue losses to farmers in highland Balochistan. In the northern areas bordering Punjab Province the probability of exceeding 300 mm is as high as 90% while towards the east in Loralai and south in Khuzdar districts the probabilities are between 10 and 30%. In Kalat, however, it is less than 10% (Kidd et al. 1988).

Rainfall over 300 mm in the 1989/90 season caused a yellow rust epidemic and as a result many farmers in highland Balochistan requested official assistance in assessing the damages and losses to the wheat crop. Consequently, a disease incidence survey was carried out in Loralai, Kalat and Khuzdar districts. The objective of the survey was twofold: to determine the disease intensity in three different areas of highland Balochistan and to obtain information about its associated economic losses.

The survey was conducted during May and June of 1990 in collaboration with the AZRI Agronomy and Germplasm groups and the Provincial Department of Agriculture. Fifty farmers were interviewed from the Duki and Mekhtar areas of Loralai and 30 farmers each from Kalat and Khuzdar districts. The Duki and Mekhtar sample included mostly irrigated and rainfed wheat farmers respectively, so that the disease intensity and losses could be determined under different moisture levels. Farmers with both infected and non-infected crops were interviewed. In addition, field measurements were conducted to evaluate the extent of infection. In the absence of data on the number of hectares cultivated to wheat in the 1989/90 season for each district, the number of hectares cultivated to wheat in the previous season was used to estimate farmers' gross revenues and losses.

Ninety-nine percent of the farmers were growing local white or red seeded wheat varieties, or a mixture of the two. In contrast, only 1% of the farmers were growing improved varieties such as Zarghoon and Pak 81. In Duki, where most of the farmers have access to irrigation, no farmers were growing improved varieties under irrigated conditions.

A comparison of the gross revenues of the three districts without and with infestation is presented below. In the three districts the estimated grain gross revenues **without infestation** under the good rainfall conditions of 1989/1990 were Rs 244 million compared with estimated straw gross revenues, which were Rs 238 million (Table 12). The estimated gross revenues of straw in Loralai were about two-thirds of the gross revenues of grain. In contrast, in Khuzdar and Kalat the gross revenues of straw were slightly above those for grain. The estimated grain gross revenues **with infestation** in the three districts were Rs 123 million with corresponding estimated straw gross revenues of Rs 161 million (Table 12). The estimated gross revenues of grain in Loralai were 82% of the gross revenues of straw whereas in Khuzdar and Kalat the estimated gross revenue of grain were 74% of the gross revenues of straw. These estimates reveal that straw is as valuable as grain in the absence of yellow rust and even more valuable when there is an epidemic.

There are biological and economic reasons for these results. From the biological standpoint, a severe attack of yellow rust caused lower total dry matter production and harvest indices compared to the average across several seasons and locations in highland Balochistan. The weighted average of infestation rates were 88, 58 and 77% in Loralai, Kalat and Khuzdar districts, respectively. The lower infestation in Kalat could be related to later planting, which is usually practised there, and to lower temperatures associated with higher altitudes. The harvest indices of diseased plants sampled were 0.124, 0.190 and 0.136 at Loralai, Khuzdar and Kalat, respectively. In contrast, the average harvest index of local wheat landraces in highland Balochistan is 0.266 (Ali et al. 1989).

On the economic side, different farm prices compounded the differences in the losses in gross revenues in the different districts. In Khuzdar and Kalat, the value of grain was 2.50 Rs/kg while in Loralai it was 3.00 Rs/kg.

Table 12. Estimated grain and straw gross revenues and losses due to yellow rust infestation.

District		Gross Revenue: Without infest.[1] (A)	Gross Revenue: With infest.[2] (B)	Losses (A-B)	Grain and straw losses	Loss share
		Rs. millions			(%)	(%)
Loralai: Duki	Grain	23.52	5.77	17.75		
	Straw	16.68	6.42	10.26	28.01	14
:Mekhtar	Grain	30.62	12.23	18.39		
	Straw	21.72	15.38	6.34	24.73	12
Khuzdar	Grain	86.80	37.09	49.41		
	Straw	91.04	47.41	43.63	93.34	47
Kalat	Grain	103.50	66.28	37.22		
	Straw	108.55	92.18	16.37	53.59	27
Total	Grain	244.44	123.37	123.07		
	Straw	237.99	161.39	76.60	199.67	100

[1]Grain (straw) yield without disease x cultivated area x farm price.
[2]Grain (straw) yield with disease x cultivated area x degree of infestation x farm price plus the value in column A for grain (straw) multiplied by the degree of non-infestation.

Note: In 1988/89 the cultivated area in Duki, Mekhtar, Khuzdar and Kalat was 8,000, 16,200, 43,400 and 55,200 hectares respectively (Government of Balochistan, 1990). Grain farm prices were Rs 3.00/kg in Loralai district and Rs 2.50/kg in Khuzdar and Kalat districts. Correspondingly, straw farm prices were Rs 0.56/kg in Loralai district and Rs 0.69/kg in Khuzdar and Kalat districts. Correspondingly, the farm price of straw was 0.69 Rs/kg in Khuzdar and Kalat while it was 0.56 Rs/kg in Loralai. Higher demand for straw in the lower rainfall areas probably contributed to higher prices.

Because of the severe epidemic, most of the farmers in the surveyed areas preferred to graze their goats and sheep on the wheat fields, as they anticipated little or no grain production and reckoned that the labour charges for harvesting and threshing would exceed the gross revenues from the grain sales.

Total district losses in grain gross revenues were 62% while the losses in straw gross revenues were 38%. The share of total losses for Loralai was only 26% compared to 47 and 27% for Khuzdar and Kalat, respectively (Table 12). Khuzdar and Kalat accounted for 70% of the grain and 78% of the straw gross revenue losses. Interviewed farmers in Loralai cultivated 48 ha of wheat, and farmers in Khuzdar and Kalat cultivated 15 and 18 ha, respectively. Thus, the total estimated wheat losses per farmer[1] were Rs 109,090 in Loralai where there are 504 farmers, compared to Rs 32,260 in Khuzdar and Rs 17,474 in Kalat where there are 2893 and 3,067 farmers, respectively.

Two severe outbreaks of yellow rust have occurred in highland Balochistan during the last decade (Nagy et al. 1989a). Even though the probability of more than 300 mm rainfall is low in the area, occurring only once every five to seven years, it is high enough to pose a serious risk of severe losses to wheat growers. Identification and release of yellow rust resistant wheat varieties is therefore one of the most important strategies for reducing economic losses to farmers in highland Balochistan.

Survey on Camel Utilization and Practices in Highland Balochistan

(G. Farid Sabir, A. Afzal, Nisar Ali Shah)

The camel population in Balochistan has increased very rapidly over the last 2 decades, from 46,000 in 1965 to 349,000 camels in 1986. This increase has been the highest amongst the provinces of Pakistan (Table 13). Balochistan, with 4.9 million people, has less than 5% of the human population of Pakistan (Buzdar et al. 1989b) while it has 36% of the country's camels. Per capita camel availability is about 1 camel per 14 inhabitants.

Camels are widely utilized for diverse farming activities and for transportation in the rural and urban areas. However, their place in the farming systems has not been studied. A camel survey was conducted by AZRI to provide base-line information about camel utilization for draft purposes and

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[1]Grain and straw losses divided by the number of hectares cultivated to wheat during 1988-89 (Table 12) and multiplied by the number of hectares cultivated to wheat per farmer interviewed.

Table 13. Population (000's) of Arabian camels in Pakistan

Province	1962	1965	1972	1976	1980	1986[1]	Provincial share[2](%)
Punjab	210	239	262	338	357	321	34
NWFP	27	45	17	95	176	70	7
Sindh	—	149	71	144	148	218	23
Balochistan	--	46	87	212	171	349	36
Total	237	479	437	789	852	958	100

[1]Government of Pakistan. "Pakistan Census of Livestock 1986". Agricultural Census Organization, Statistics Division, Lahore, June 1989.
[2]1986.

transportation at the farm level. This information will allow AZRI researchers to describe and diagnose the current situation in highland Balochistan.

Informal and formal surveys were conducted in the summer of 1989 in three areas of highland Balochistan, with a total of 136 camel owners being interviewed. Of the farmers interviewed, 57% said that they expected to continue using camels or oxen during the next ten years and of those farmers, 55% said that they preferred camels over oxen. While 32% said they already use tractors for field preparation, another 35% said they would like to use them. Of those who would like to use a tractor, 97% said that they could not afford one because tractor costs are considerably higher than those of camels. Due to tribal or communal land ownership, camel foraging costs are free. In addition, the small size of the landholdings may influence the preference for camels over tractors. Each camel owner had 2.8 ha of irrigated land, and 13 ha of non-irrigated land, of which 7.7 ha was sailaba (receiving some run-on from ephemeral floods) and 5.3 ha was kushkaba land (which gets no run-on from outside.). The average number of camels owned was 5.2, which results in 3 ha of total cultivable land per camel.

Female camels are preferred for transportation, while 60% of the camel owners said that they preferred using male camels for ploughing, planking and planting. The age of camels is an important factor in the estimated value given by the owners. Camels of less than a year old are worth Rs 1200/hd. As they reach 7-10 years and are trained for transportation and agricultural practices, their value increases up to Rs 5520/hd. From 11 years on their value slightly declines.

Camel draft power is very important in dryland farming. When camel owners provide services to other farmers they make Rs 2700 per year for ploughing, planking and sowing and Rs 2000 for crop transportation. These figures exclude the considerable benefits the camel owner gets from having his own animals. Rs 8350 per year are earned transporting wood while only Rs 250 are earned transporting people; camel owners felt that the latter was a service to their communities.

It is unlikely that tractors will displace camels for agricultural practices, given the low returns from investment in traditional dryland agriculture in highland Balochistan. Camel owners, as well as owners of small ruminants, would benefit from better forage availability in the winter due to decreased supplemental feed costs and better resistance to diseases. Thus, research aimed toward alternative sources of winter forage should benefit camel owners as well as other farmers.

Marketing of Small Ruminants and Meat in Highland Balochistan
(Khalid Mahmood)

Ninety percent of the livestock produced in highland Balochistan is produced under transhumant and nomadic production systems, 96% of the land is under tribal or communal ownership and only 4% is state owned (Nagy <u>et</u> <u>al</u>. 1989b). Communal rangeland ownership has resulted in severe degradation of the rangelands resulting in low offtake and low carcass weights. Offtake occurs throughout the year but it is higher in early spring (February-March), late summer (July-August) and during the migration from the highlands to the Indus Valley in autumn. The main concern of most of livestock producers in highland Balochistan is to maintain their flocks and increase their numbers rather than increase their income. Producers are conscious of the convenience of selling those animals that are old, unproductive or infertile but their production schemes are not based on price seasonality or quality factors that affect market prices.

A first step in diagnosing the livestock/meat market situation in highland Balochistan is to estimate the price of a series of marketing services which is the outcome of the demand and the supply for such services, or market margin. In addition, it is important to determine the constraints faced by various components in the marketing chain, and to look at the distribution of margins. The objectives of this study were: 1) to identify services, and constraints affecting the different elements in the livestock/meat marketing chain, 2) to estimate the costs associated with those services as well as the distributive margins and 3) to suggest guidelines for future research to improve the marketing system. A survey was conducted at three locations in highland Balochistan during July, 1989: Sanjavi (Loralai District), Kuchlak (Quetta District), and Zarchi (Kalat District). Interviews were held with 23 producers and four village dealers in Sanjavi. Sixteen producers and two village dealers were interviewed in Kuchlak and 25 producers and four village dealers were interviewed in Zarchi. Five wholesalers, five commission agents, 10 butchers and 20 consumers were interviewed in Quetta.

Services, costs and constraints of the elements in the marketing chain

The marketing of livestock and meat involves many agencies and intermediaries and it is difficult to be precise about their exact number in the operational chain. A schematic representation of the marketing chain is shown in Figure 8. The results presented below are aggregated figures of both sheep and goats based on carcass dressing percentages of 50 and 55%, respectively.

Producers: large in number and small in size, highland Balochistan producers are widely distributed and have no coordination among themselves. They mostly dispose of their livestock at the village level to avoid the cost and inconvenience of transporting them to town markets. In addition, because they sell small numbers to meet urgent cash demands, the producers are not in a position to bargain very effectively. The producers interviewed had an average flock size of 85 head of which 25% were goats. The average liveweight for sheep and goats was 24.1 kg which produced a 12.6 kg carcass with an estimated farm price of Rs 496. Our offtake estimation is 26%, which if multiplied by 11.7

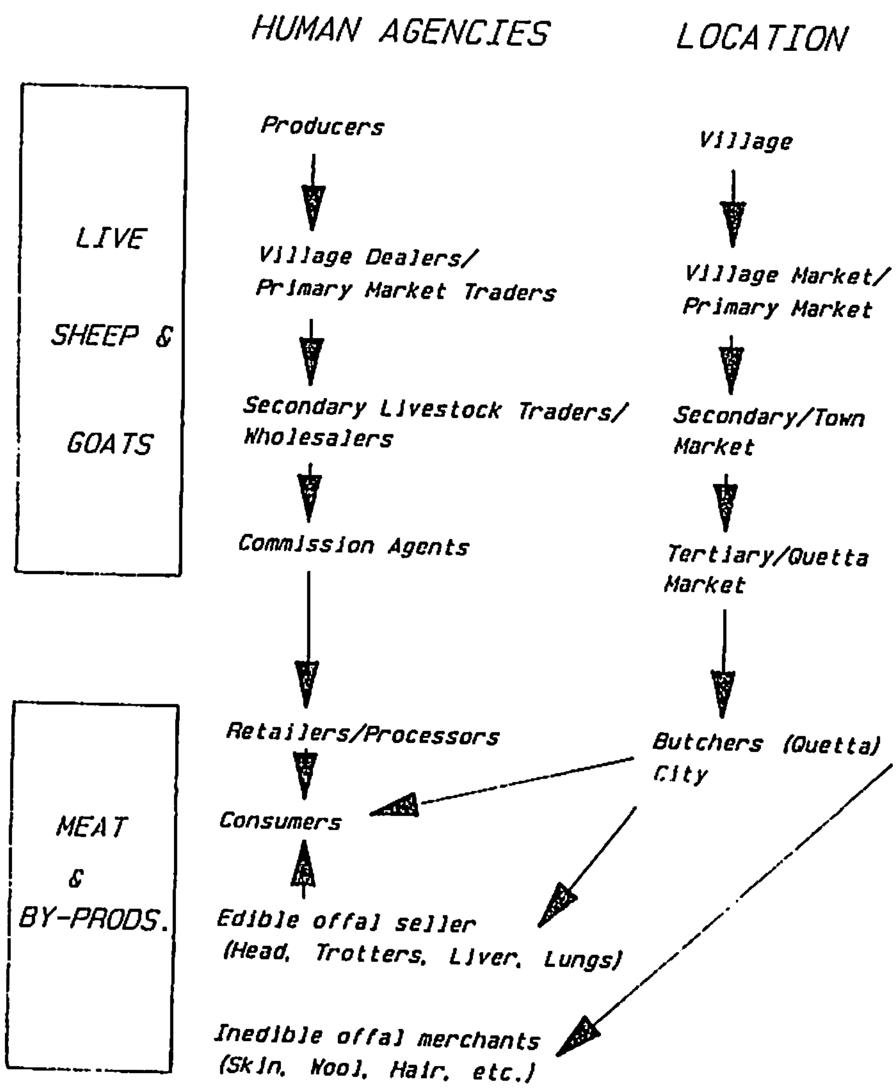

Figure 8. Components of the marketing chain.

million head in highland Balochistan and by the average carcass weight, yields 38,000 tons of meat per year.

Producers felt that they were receiving an inadequate proportion of the end price paid by the consumers. In some instances the producer might attempt to time the sale in order to take advantage of seasonal fluctuations in demand, but in general the expected price was not the major determinant of the decision to sell an animal. Even though most livestock production in highland Balochistan takes place under transhumant and nomadic production systems and producers do not perceive themselves as "market oriented", they do incorporate the liveweight of the animals in the estimated price as shown by the equations below:

$$\text{Sheep price} = 42.4 - \underset{(0.042)}{0.161}\ \text{LWT} \qquad R^2=19\%,\ n=64$$

$$\text{Goat price} = 47.3 - \underset{(0.046)}{0.270}\ \text{LWT} \qquad R^2=46\%,\ n=64$$

Prices are in Rs/kg and LWT is liveweight. Standard errors are in parentheses. Factors not included in their estimated prices are discussed below.

Village dealers/primary market traders: primary market traders purchase animals from the village areas and sell them to the secondary livestock traders in town markets (wholesalers), such as Loralai or Kalat. Animal transportation costs, octroi (a local tax), feed costs, village dealer transportation costs and other miscellaneous costs amount to Rs 29/hd. The interviewed dealers were hesitant to provide information about livestock smuggling to Iran but acknowledged its existence.

Livestock traders at the secondary and tertiary markets: wholesalers in small town markets buy from the village dealers and transport their livestock to larger tertiary markets such as Quetta, Karachi or Lahore. Wholesalers sell through the commission agents to the butchers in Quetta or else they export their livestock to the Punjab or Sindh. Interviewed livestock traders in Quetta (the major market in highland Balochistan) mentioned that the commission agents were the necessary link with the buyers in order to bargain and arrange livestock sales. The wholesaler provides transportation to Quetta at Rs 0.10/Km/hd, feeds the animals, pays the octroi (a local tax), and absorbs the costs of animal shrinkage during transportation over distances which can be up to 250 Km. These aggregated costs are Rs 56/hd. In addition, an average fee of Rs 20/hd is paid to the commission agent. The Quetta market is located on city property with no formal charge for its use, but the city authorities collect and sell the manure. Commission agents are not required to pay any license fee or other government levies but they pay for the social costs of the purchasing process (tea and biscuits for wholesalers and butchers); these social costs averaged Rs 2.4/hd.

Animal marketing in Quetta, as well as in other markets, suffers from various difficulties which can affect profit. There are no watering and shed facilities for the animals and middlemen. During the slack season from November to February, livestock marketing is more expensive as variable costs increase. The high prices of animals, particularly in the winter season, are due principally to the migration of the producers with their livestock to the Indus Valley, which increases costs of transportation and feeding.

Butchers: sheep and goat meat is sold fresh and without refrigeration in small shops within eight to 10 hours after slaughter; little, if any, meat is carried over to the following day. Meat handling and transport from the primitive abattoirs to the retail market or to the retail outlets is generally done by donkey, horse or camel carts, the traditional transportation. The retail price of meat is controlled in cities and towns by the local administration or the government departments concerned. Average marketing costs of Rs 27/hd include feeding and slaughtering. Most of the gross returns to butchers come from meat sales but 16% is received through the sale of by-products such as skin, head, feet, stomach, and offal.

In Quetta there is no facility to provide rest or shelter to the animals before slaughter. There are 17 registered slaughter houses in Balochistan with appropriate processing facilities (Dr. Dur Mohamad, Director General, Livestock Department, Quetta, personal communication). Nevertheless, there are a large numbers of unregistered slaughter houses in Balochistan with unhygienic, unsanitary and poorly managed facilities, causing wastage of by-products. Lack of cold storage and chilling facilities in the slaughter houses forces the slaughtering of smaller numbers of animals as they have to be sold on a daily basis.

There is no small or large scale industry which buys (uses) the by-products to process them into useful products such as poultry feed, blood meal, and calcium diphosphate bone meal. There are not even transportation arrangements to collect blood, bones, hooves, and offal. Thus, most of the by-products go to waste and this results in further economic losses. Traditional methods of carcass transportation to the butchers cause the contamination of carcasses with dust and dirt and lower the quality of the meat offered to consumers.

Consumers: the average family size in Quetta varies from 5 to 8 adults âveraged over the different income groups. Per capita meat consumption averaged 19.4 kg/year, and this is higher than the national level of 13.2 kg/year (Government of Pakistan, 1989). Results of the survey showed that meat consumption is proportional to the income of the consumers. Poultry and beef are substitutes for mutton, but the latter is highly preferred for cultural reasons; the demand for meat is reflected in the prices which are 40, 26 and 50 Rs/kg for poultry, beef and mutton, respectively. Major problems faced by consumers are the unhygienic conditions at the slaughter houses and the unprotected exposure of meat in the shops; these cause a high incidence of gastro-intestinal diseases. Absence of grading also results in lack of confidence about quality among the consumers.

Distributive margins and development of the meat industry

The average price paid by consumers is Rs 716/hd and the average price paid to producers is Rs 496/hd. The Rs 220 marketing margin represents 30.5% of the price paid by the consumer; it is shared by the intermediaries in the marketing chain. The distributive margins in the marketing chain are broken down into costs and profits in Figure 9. The costs exclude labour, management and risk charges; therefore, the actual profits may be considerably less than those in Figure 9.

The commission agent is often portrayed as taking advantage of the other intermediaries or of being responsible for forcing down returns to the producer.

However, it is not generally acknowledged that the commission agents do the bargaining based on their up-to-date knowledge of the actual market conditions. Even though there are no institutional regulations in the livestock and meat market other than the octroi paid by traders, the market system provides a series of services that reflect a relatively high degree of development. Most of these services could of course be improved for the benefit of both the consumers and producers; the overall volume of the market could be higher, the quality of the meat could be more uniform and some marketing costs could be decreased.

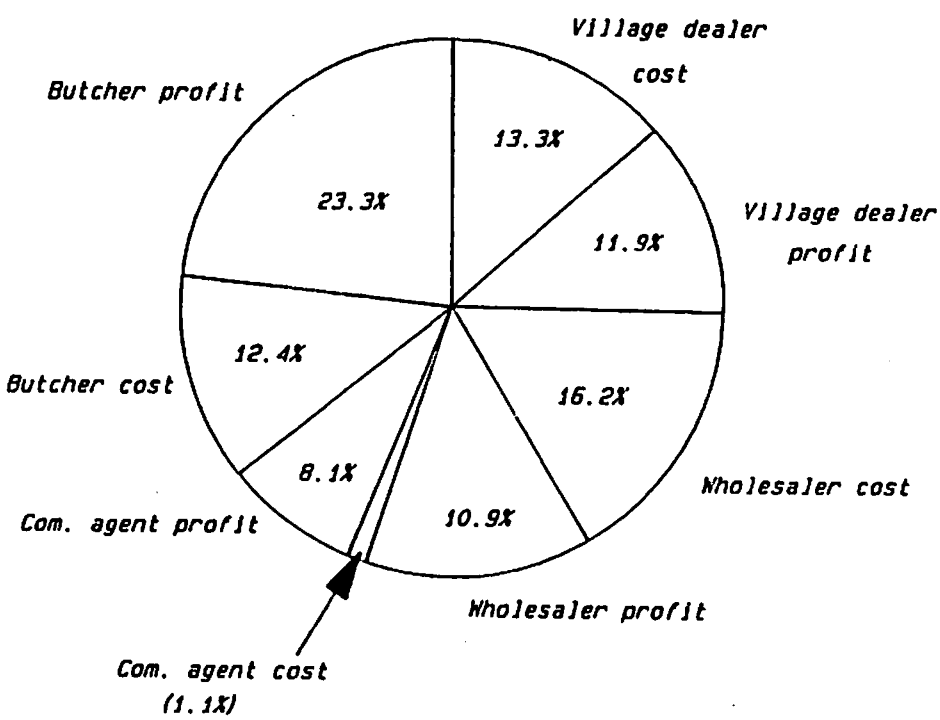

Figure 9. Distributive margins in the livestock and meat market in highland Balochistan.

Price discovery of sheep and goats, whether at a producer's farm, at a market, or in transit, is on a person-to-person basis. There are no auctions at markets, but rather numerous individual transactions taking place simultaneously on a willing buyer-willing seller basis. The main factors affecting the price of slaughter animals are the quality, sex, age, carcass weight, skin condition and the availability of animals. Observations of market agents suggest that market prices for sheep and goats are 10-20 percent higher in winter relative to summer in Balochistan. Interviewed market agents reported that the average price of male animals is about 10 percent higher than that of female animals.

Developing the meat industry in highland Balochistan is a complex task. On the one hand, improvement in livestock and meat marketing cannot be very significant if the signals sent by the market to improve offtake and quality are not perceived by the producers. On the other hand, because of the land tenure system prevailing in Balochistan, producers are not market oriented and do not appreciate potential opportunities to improve their income. Extension efforts should be directed towards improving producer awareness about market prices and about the need for careful planning of output according to seasonal market fluctuations. This appears to conflict with the "security seeking" nature of transhumant and nomadic pastoralists, but it is a possibility that needs to be tested in the area, and would be less disturbing to producers than proposals to privatize landholdings in an effort to induce market oriented production.

Limitations of this study and recommendations

As a first attempt to understand the livestock situation in highland Balochistan this study has several limitations. First, respondents were hesitant to give correct information on their incomes and profits from livestock transactions. Also, there was a virtual lack of records amongst producers and sales intermediaries involved in the retailing of livestock. Even though the Quetta market makes up 60% of the market operations in highland Balochistan, it does not comprise the entire market. Furthermore, this study includes neither seasonal price fluctuations, nor price differentials between breeds, sex, age of the animals or their body condition. Thus, our estimations of margins in the different components of the marketing chain are a generalized glimpse of the market situation in the summer of 1989.

Studies should be undertaken to evaluate the potential for adjusting offtake to coincide with periods when market conditions are favourable. Finally, apart from the complexities associated with the tribal and communal land tenure and transhumant and nomadic livestock production systems in highland Balochistan, marketing studies can provide a better understanding of the apparent lack of interest of producers in actual and potential incentives determined by livestock and meat supply and demand.

The AZRI Modelling Effort

The very limited areas under irrigation or with the possibility to develop irrigation schemes such as reservoirs, canal networks and tube-wells in highland Balochistan, encourage innovative thinking for the economic planning of the drylands. AZRI has been conducting research for the last six years in the drylands of Balochistan; however, the knowledge generated has not been integrated into a managerial tool that merges field observations, empirical equations, and technical, economic and social constraints. An ex-ante evaluation of animal husbandry practices (Nagy et al. 1989c) was the first attempt at AZRI to do any economic analysis with a modelling approach.

The objective of the AZRI modelling effort is to develop a whole farm planning model to assess sequential decision making in highland Balochistan under conditions of uncertainty. The model incorporates the following components: climate, annual crops, a perennial bush (A. canescens-fourwing saltbush), range plants and livestock and socio-economic constraints. Included in the model are: 1) highly uncertain and erratic climatic conditions which determine crop and livestock production, 2) land tenure and social structure and 3) market price fluctuations. In its initial stage of development a simulation approach will be followed because of its flexible capacity to incorporate many elements in each component without jeopardizing its tractability. In subsequent stages, dynamic optimization will be used for individual components to keep the dimensionality of the model within the limits of personal computer equipment.

Applications of the model are numerous; however, the most logical ones are those that involve the evaluation of AZRI technologies applied to specific social organizations associated with land tenure. Furthermore, the model can be used to generate sound agri-business schemes under different planning horizons. These production-marketing schemes can be brought to the attention of potential investors, establishing a linkage between AZRI research and the private sector.

Conceptual Model

The crops are wheat, barley, and vetches. Wheat is cultivated for human food security reasons and also for straw production to feed livestock and for use in building mud-walled structures. Barley is grown as a fodder in the form of grain or straw (Nagy et al. 1989a). Vetches (*Vicia* sp.) are fodder crops that can survive on very limited water, and are highly resistant to cold temperatures in winter. They have been identified as the most promising species for forage production (Rees et al. 1989d). The perennial shrub fourwing saltbush produces valuable fodder, particularly during the time when native range forage quality and quantity is low during the winter months (Atiq-ur-Rehman et al. 1989). This perennial shrub plus the other crops that provide straw or hay, are the linkages with the range and livestock components of the crop-livestock systems in highland Balochistan. The livestock component consists of sheep and goats kept under extensive grazing conditions. As in other regions in Western Asia and North Africa, the size of the animal inventory in highland Balochistan has grown beyond the carrying capacity of the fragile arid ecosystems. The range plant and livestock components comprise the largest proportion of the model to be developed in terms of their dominance in highland Balochistan with ranges occupying approximately 93% of the land. Land tenure and marketing constraints will be embedded in different versions of the model corresponding to private ownership, tribal and government land (Buzdar et al. 1989a and 1989b).

Synthetic Model

The proposed model can be written as follows:

$$Z_u = \sum_{i=1}^{N} [\, \Phi \, (\underline{Y}\, \underline{P}^T - \underline{Y}\, \underline{W}^T) \,]_i$$

Subject to: $\underline{Y}$ = f(δ, land, labour and capital)

where:

Z is the net present value, $\underline{Y}$ is a vector of outputs, sheep, goats, wheat, barley, vetches, including intermediary products. $\underline{P}$ is a vector of commodity prices, $\underline{W}$ is a vector of production and marketing costs, N is the number of years in the planning horizon and Φ is the discount factor. $\underline{P}$ and $\underline{W}$ are functions of supply and demand and in the regional or national stocks of agricultural commodities. This can determine seasonal variations and long term fluctuations in prices, for example livestock cycles. In addition, some elements of $\underline{P}$ or $\underline{W}$ can be included as stochastic variables to represent market uncertainty.

The controls, u, are exerted in different components of the farming system at different times in one season. These controls are specific water-related activities, plant/livestock practices and marketing decisions.

Climatological component

Balochistan is characterized by erratic rainfall distribution patterns and skewed distributions of rainfall events interacting with extremely low and high temperatures (Kidd et al. 1988). Rainfall and temperature are the driving variables for the AZRI model.

Available climatic information can be used to provide simple but effective tools to simulate the role of these key variables in the agricultural and livestock systems of highland Balochistan. For the sake of simplicity, δ represents the complex interaction of the climatic variables on each of the agricultural and livestock commodities. Depending on the specific component of the model, δ will be a disaggregated variable, that is, probability distributions of daily rainfall, probability distributions of accumulated precipitation during the plant growth period, etc.

Annual crop component

A series of equations for water use efficiency have been developed from the Agronomy group at AZRI (Rees et al. 1989b, 1989c and 1989d).

$$Y_{k,a} = WUE_{k,a} (WAI-YO_{k,a})$$

where:

Y = is the yield (kg ha^{-1}).

WUE = is the water-use-efficiency (kg DM mm^{-1} ha^{-1}).

WAI = is the water availability index calculated as the soil moisture at planting plus rainfall during the growing season (mm).

YO = minimum WAI necessary to produce any level of Y.

k and s are the species and the phenological stage, respectively.

Rainfall and temperature are driving variables of the plant response equations. Rainfall is a stochastic variable that has known probability distributions. Temperature is included to calculate the evaporation losses during the monsoon rain period, June to August. After evaporation losses have been calculated, the precipitation that is stored in the soil profile is estimated at planting time. Water harvesting techniques (Rees et al. 1989a) are incorporated into the system to partially or totally offset water deficits, and spillways are included to avoid water logging. When soil moisture is partially a controllable variable, it is possible to add fertilization with N or P or inoculation treatments using Rhizobium species for different varieties of species, k, conditioned to soil moisture conditions and expectations of rainfall.

Managerial variables are water harvesting techniques, species, varieties, fertilization and inoculation treatments. The interplay of these decisions will determine a spectrum of crops to be planted in the cultivable land of a given farm. As will be discussed below, the socio-economic constraints will determine the inputs and outputs of the combined agricultural systems.

Perennial crop component

Because of the perennial nature of saltbush a multi-period equation is the most appropriate:

$$Y = \Sigma \Sigma \Sigma [(SC + GTH - H/G)_j]_{h,i}$$

where:

SC = standing crop (kg ha^{-1})

GTH = rate of growth (kg ha^{-1} per intraseasonal period)

H/G = is the amount harvested/grazed (kg ha^{-1}) which is a controllable variable.

j = the plant component which is harvested/grazed material (twigs and foliage, seeds or woody material).

h and i represent respectively the intraseasonal periods and the seasons in the planning horizon.

The model should represent the perennial plant as a capital asset in the sense that it can be sustained and increase or decrease with appropriate or inappropriate management. The yield of a forage reserve depends on several factors:

$$Y_{h,i} = f(SET, ST, SD, DENS, AGE, \delta, IRR, H/G)$$

where:

SET = set up treatment

ST and SD = soil type and depth, respectively

DENS = plant density (plants ha^{-1})

AGE = age of the stand

IRR = irrigation (mm ha^{-1})

The saltbush can provide feed during the time forage quantity and quality are low, thus establishing a linkage between the managerial activities for the forage reserves including water harvesting systems, harvesting intensity and grazing management, and the livestock component. The above functions that characterize the responses of fourwing saltbush to weather and management variables (and analogous functions for range plants and livestock described below) are unknown at the moment. Published information, field observations and information being gathered at the present time (Khan et al. 1990) will be used to derive these functional forms.

Range plant component

For the sake of simplicity the model will assume a homogeneous stand of native range plants.

$$Y = \Sigma \, \Sigma \, f(\delta, CO, GZ)_{h,i}$$

where:

CO = carry-over biomass from the previous grazing season (kg ha^{-1})

GZ = grazing intensity in the current intra-seasonal period (kg ha^{-1} which is a function of liveweight per unit of area)

h and i represent, respectively, the intraseasonal periods and the seasons in the planning horizon.

Range livestock component

The livestock component can also be expressed in a multi-period form.

$$Y = \Sigma \, \Sigma \, \Sigma \, \Sigma \, \Sigma \, f(AH, FQQ, SLP)_{h,i,j,k,l}$$

where:

AH = animal husbandry practices

FQQ = quantity and quality of native range vegetation

SUP = supplementation

h and i represent respectively the intraseasonal periods and the seasons in the planning horizon; j, k and l represent respectively, the species, sex and the age group. Discrete animal responses to husbandry practices have been reported by Nagy et al. (1989c).

Socio-Economic Component

The net present value, Z, was chosen as the performance criterion for different managerial strategies in the broad set of activities that can be modelled. This criterion can be implemented in both simulation and optimization approaches. Risk analysis can be used to assess the likelihood that a certain technological package will be adopted by the farmers in upland Balochistan (see Nagy et al.1989c).

The socio-economic component includes the accounting of owned or possessed land, land which could be leased, irrigation, labour, machinery and capital availability. Any economic decisions to be made throughout the planning horizon will be evaluated in this component with access to weather, plant, livestock and market information. Simple hypothetical scenarios will be included. These scenarios involve combinations of increasing and decreasing prices in input and outputs in order to assess the effect on demand of production inputs and supply of certain agricultural commodities. Seasonal and intraseasonal random fluctuations in the inputs and outputs will be included to reflect market uncertainty. Representative sites and representative social structures present in highland Balochistan will be selected.

Future Research

Three major activities deserve careful attention in the future: economics of water harvesting, livestock and meat marketing, and rangeland utilization as a common property problem.

Water harvesting

The economic analysis of four years of experimental results (1985/86 to 1989/90) should receive first priority. An ex-ante evaluation using rainfall exceedence probabilities and water use efficiency equations will permit the evaluation of long run scenarios. This research will allow the analysis of technology adoption.

Livestock and meat marketing

First, there is a need to monitor livestock prices throughout the year and to relate them with forage constraints, migration patterns of transhumant and nomad pastoralists and demand from major population centers in order to better understand the degree of sophistication of the livestock and meat market. Next, it is very likely that wholesalers and commission agents incorporate factors such as animal condition, sex, breed and age into their price equation, but producers are not aware of that or they do not perceive the potential gains of adjusting production schemes to more favourable market conditions. Studies should be undertaken to evaluate the potential of adjusting offtake to periods of high demand.

Rangeland utilization

The complexities associated with the tribal and communal land tenure and transhumant and nomadic livestock production systems in highland Balochistan need to be understood in the context of the economics of common property resources. This study will contribute to deriving more realistic expectations of our research impact in production and marketing of agricultural and livestock commodities in highland Balochistan.

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Chapter 5

AGRONOMY GROUP

(ICARDA Advisor - A.Y. Allan)

(AZRI STAFF: S.H. Raza, S. Mehmood and M. Islam,

and for part of the year: F. Rehman, Zahid Ali and A. Samiullah)

Introduction

The Agronomy Advisor for Phase 1 of the MART/AZR Project completed his assignment in October 1989. During his four years at AZRI the results of the agronomic research from 1985 to 1989 were presented at various national and international workshops and conferences, and were prepared for publication in several MART/AZR Research Reports and international scientific journals. His replacement arrived in late March 1990, thus there was a six month gap which spanned most of the 1989/90 sowing and growing season. The AZRI staff numbers in the Agronomy group went down from six to three during the year due to departures to other postings, for overseas training and for marriage.

The agronomy research trials conducted were all purely rainfed. The local name for such rainfed cropping is "kushkaba" where no run-on from outside flows on to the cropped area; where there is some run-on from flood water in higher areas the term "sailaba" is used. All the trials were kushkaba except at Kolpur where all the trials except the water harvesting one were sailaba.

Objectives

The main objectives of the field experiments carried out in 1989/90 were to:

- continue the catchment basin water harvesting (CBWH) trials started in 1986/87, at existing and additional sites,
- evaluate the yields of the promising forage legume, woollypod vetch (*Vicia villosa* ssp. *dasycarpa*), under different seed rate, inoculation and fertilizer treatments, and
- measure the effects of other interventions such as farm yard manure (FYM), fertilizers and intercropping on the yields of wheat, barley and vetch.

Climatic Conditions

Table 14 lists the experimental sites, their altitudes and their monthly rainfall recorded during the 1989/90 season. The rainfall from July to December 1989 was insufficient for planting crops in winter and it was only after good rain in late December/early January that the agronomy trials could be planted. There were heavy rains from then until March but they stopped abruptly towards the end of that month. The rainfall season was therefore rather short but quite copious which caused some waterlogging during February. The favourable rainfall conditions in several districts led to an epidemic of yellow rust (*Puccinia striiformis*) which devastated wheat yields; wheat in the agronomy trials at Loralai was virtually wiped out. There were no serious late frosts to damage these spring plantings but very dry desiccating winds in April caused some shrivelling of grain during maturation.

Table 14. Rainfall (mm) at trial sites (1989/90).

	Sites (altitude, m)			
	Dasht (1750)	Mastung (1650)	Kovak (1950)	Quetta (1700)
July (1989)	27.6	0.0	23.2	0.0
August	0.0	0.0	0.0	0.0
September	0.0	0.0	0.0	0.0
October	0.0	0.0	0.0	0.0
November	2.7	2.9	0.0	5.7
December	10.0	37.0	15.0	15.0
January (1990)	76.3	81.6	22.8	47.4
February	132.4	96.0	40.1	130.0
March	10.1	24.2	4.6	36.1
April	3.2	0.0	0.0	0.0
May	0.0	0.0	4.4	0.0
June	0.0	0.0	0.0	0.0
Totals	262.3	241.7	110.1	234.2

Agronomy Trials

The agronomy trial sites are located around Quetta in the Dasht, Kolpur, Mastung, Kovak and Loralai valleys on gently-sloping or almost flat land. The soils, classified under the FAO system as alluvial yermosols, are quite alkaline with high lime contents and low available phosphate (Table 15). They are mostly silty clay loams or silt loams and have very poor structural stability. As soon as the soils are wetted the surface layer slakes and becomes muddy or soupy. Fine particles clog the pore spaces and the top wet layer becomes much less permeable to further rainfall so that run-off starts quite soon. In addition, after drying out, the surface forms a crust which can become quite hard and this can severely impede seedling emergence. Due to the slow rate of infiltration through such hard crusts, the proportion of rainfall which run-offs from subsequent showers is greater. These soil characteristics give rise to potential opportunities for water harvesting.

Table 15. Soil analytical data from trial sites.

Sites	pH	Lime (%)	Organic matter (%)	Kjeldahl N (ppm)	P-Olsen (ppm)
Kovak	8.5	22.0	0.54	426	8.2
Mastung	8.5	25.0	0.55	430	6.2
Dasht	8.4	26.1	0.53	439	6.3
Kolpur	8.3	22.5	0.59	474	8.6
Loralai	8.4	23.4	0.40	460	5.0

Vetch seed rate trials. Trials carried out by AZRI since 1985 have shown that woollypod vetch can produce high yields of fodder provided moisture availability is adequate; its water requirements are similar to those of wheat. Seed yields, however, have been low suggesting that the usual seed rate of 90 kg/ha may be too high for optimum seed yields. Good responses to seed inoculation with nitrogen-fixing bacteria (Rhizobium leguminosarum) have been obtained in some previous trials and also some responses to phosphate fertilizer have been seen.

Trials were conducted in 1989/90 to measure both herbage and grain yields from five seed rates - 30, 60, 90, 120 and 150 kg seed/ha - with and without inoculum, and with and without phosphate. A factorial design with three replications per site was used and the trial was laid down at Kolpur, Kovak and Loralai. Vetch in the Kolpur trial grew well and quite uniformly yielding usable information summarised in Table 16. But the crop at Loralai was spoiled by a very bad attack of army worm caterpillars (Spodoptera sp.) which devoured nearly all the luxuriant vegetation. Extremely bad germination at Kovak resulted in the trial being abandoned.

Table 16. Yields (kg/ha) of grain and TDM from woollypod vetch seed rate trial at Kolpur under sailaba conditions (1989/90).

	Seed rate (kg/ha)						
	30	60	90	120	150	Mean	LSD(5%)
Grain	607[ab1]	705[a]	531[bc]	467[c]	412[c]	544	126
TDM	4034[bc]	4952[a]	4504[b]	4022[c]	3328[d]	4168	359

[1]Different letters in the same row mean that the corresponding values differ significantly ($P<0.05$).

The 30 and 60 kg/ha seed rates were significantly better for seed production and for TDM production 60 kg/ha was best. Both seed and TDM yields declined significantly at the higher seed rates. Ioculum increased yields significantly, but phosphate response, though significant, was small (Table 17).

Farm yard manure and fertilizer trials. Factorial trials were laid down at Kolpur, Mastung and Miangundi to measure the effects of farm yard manure at the rate of 10 t/ha, fertilizer at the rate of 40 kg N/ha and 60 kg P_2O_5/ha on Pak 81 wheat and Arabi Abiad barley.

Yields at Kolpur were higher because an appreciable amount of sailaba run-on water was received on the site (Table 18). Thus significant grain and TDM yield increases were obtained from both FYM and fertilizer application while barley outyielded wheat by 51%. At the other two sites yields under kushkaba conditions were lower and significant responses fewer.

Table 17. Main effects of inoculation and phosphate application on yields (kg/ha) of grain and TDM in woollypod vetch seed rate trial at Kolpur under sailaba conditions (1989/90).

Main effect		Grain	TDM
Inoculum:	None	488[a1]	3886[a]
	Applied	601[b]	4451[b]
Phosphate:	None	514[a]	4039[a]
	60 kg/ha	575[b]	4298[b]

[1]Different letters in the same column mean that the corresponding values differ significantly (P<0.05).

Table 18. Yields (kg/ha) of grain and TDM in farm yard manure, fertilizer and cereals trials at three locations (1989/90).

Main effects		Kolpur (sailaba)		Mastung (kushkaba)		Miangundi (kushkaba)	
		Grain	TDM	Grain	TDM	Grain	TDM
Manure:	-	1279	3118	517	1234	761	2117
	+	1582	3621	589	1300	1090	2486
Fertilizer:	-	1313	3196	562	1207	819	2109
	+	1548	3543	545	1327	1031	2494
Cereal:	Barley	1722	4201	544	1289	980	2148
	Wheat	1139	2538	563	1245	871	2455
Mean		1430	3369	553	1267	925	2301
CV(%)		12.7	6.2	17.9	18.8	14.7	13.9
LSD(5%)		133	155	73	175	100	236

Rates of nitrogen and phosphate on local white wheat. Previous trials indicated that responses to nitrogen were only obtained when the water availability to the crop exceeded about 300 mm and that responses to phosphate were generally small. These trials were carried out to test the effects of using a wider range of application rates. As already indicated the trial at Loralai was lost due to the yellow rust epidemic and therefore usable results were obtained only from the Kolpur sailaba trial.

Nitrogen fertilizer rates applied were 0, 20, 40 and 80 kg N/ha, applied as ammonium nitrate with 25% being applied at planting and 75% as topdressing, and phosphate rates were 0, 30, 60 and 120 kg P_2O_5/ha applied as triple superphosphate at planting. The trial design was a 4 x 4 factorial with three replications. There were no significant fertilizer responses (Table 19).

Table 19. Yields (kg/ha) of grain and TDM in N x P wheat trial at Kolpur under sailaba conditions (1989/90).

	Phosphate rate (kg P_2O_5/ha)				Mean	CV(%)
	0	30	60	120		
Grain	932	965	960	1019	969	19.7
TDM	2838	2895	2935	2915	2915	11.9
	Nitrogen rate (kg N/ha)				**Mean**	**CV(%)**
	0	20	40	80		
Grain	1034	894	964	985	969	19.7
TDM	2991	2943	2848	2876	2915	11.9

Intercropping of woollypod vetch and wheat. As livestock fodder is of great importance in Balochistan some studies were initiated in previous years to find out if intercrops of cereals and vetch would increase production and make harvesting easier. In 1989/90 the four treatments were: monocropped wheat, monocropped vetch, a single row of vetch sown between two rows of wheat and a single row of wheat sown between two rows of vetch. Crops were planted in a randomised complete block layout with four replications.

Yields were quite high due to the sailaba run-on at this site (Table 20). Intercropping tended to reduce the total grain output compared with pure wheat but the arrangement of one row of wheat between two rows of vetch apparently increased overall forage production.

Table 20. Yields (kg/ha) of wheat and vetch in intercropping trial at Kolpur under sailaba conditions (1989/90).

a) Expressed on pure stand basis.

	Wheat	Wheat + Vetch		Wheat + Vetch		Vetch	CV(%)	
	Pure	2 rows	1 row	1 row	2 rows	Pure	Wheat	Vetch
Grain	1204	997	550	1235	543	368	23.1	41.6
TDM	2990	2496	3640	3328	4108	2808	15.0	17.0

b) Actual yields of the crops as intercrops.

Grain	1204	(666 + 183)	(411 + 362)	368
TDM	2990	(1664 + 1213)	(2218 + 2738)	2808

Note:- 666 = two thirds of 997, 183 = one third of 550
411 = one third of 1235, 362 = two thirds of 543

c) Combined yields of the intercrops.

Grain	1204	849	773	368
TDM	2990	2877	4956	2808

Catchment Basin Water Harvesting Trials. Computer predictions were made of rainfall probabilities during different periods in the Quetta area, where the annual mean is around 227 mm, and of the amounts of run-off which could be expected from a compacted silty clay loam. These predictions indicated that in half the years an additional 100 or 200 mm could be generated from a catchment area (basin) representing the upper half or two-thirds of the total field, with the lower half or one-third of the field, respectively, forming the infiltration, run-on, cropped area.

The trials were set up with four replications at the Kolpur, Dasht, Mastung and Kovak sites. At each site there were three treatments namely, a control on which the whole area was cropped, a 1:1 catchment-to-crop area on which the upper half was a smoothed catchment, and a 2:1 catchment-to-crop area where the top two-thirds was smoothed. The catchments were set up by first ploughing with a tractor-mounted mouldboard, then pulverising and levelling the soil with a heavy tractor mounted wooden plank. Once the catchments have been set up they should remain effective for many years with only minor maintenance costs.

Only the site at Mastung gave results, the others having been rendered unusable for a variety of reasons. As already indicated in Table 14, the rain began very late in the season and then was heavy enough to cause some waterlogging, especially in the 2:1 treatments. Local wheat, Arabi Abiad barley and woollypod vetch were grown on all treatments and their yields are summarised in Table 21.

Table 21. Yields (kg/ha) of grain and TDM in catchment basin water harvesting trial at Mastung (1989/90).

	Local Wheat		Ar. Abiad Barley		Woolly pod vetch	
Treatmnt	Grain	TDM	Grain	TDM	Grain	TDM
Control	303[a1]	1707[a]	418[a]	1696[a]	203[a]	1334[a]
1:1	521[b]	2653[b]	633[b]	2924[ab]	431[b]	1832[b]
2:1	275[a]	2983[b]	715[b]	4029[b]	221[a]	2485[c]
CV (%)	20.3	11.0	18.4	31.0	14.4	13.6
LSD(5%)	129	464	188	1546	71	442

[1]Different letters in the same column mean that the corresponding values differ significantly (P<0.05).

Water harvesting increased significantly the TDM production of all three crops with the 2:1 treatment generally exceeding the 1:1 which in turn was better than the control. Grain yields were affected differently, however. The 1:1 treatment was significantly better than the control for all three crops but the 2:1 plots of wheat and vetch were not any better than the control, and were significantly poorer than 1:1 plots. Waterlogging was observed for a slightly longer period in the 2:1 than in the control and 1:1 and this apparently affected grain production in the wheat and vetch plots more than in the barley. Barley seemed to be more tolerant of the temporary waterlogging.

These findings were in line with those of the previous years and confirmed that CBWH has a modest potential for increasing yields and reducing the risks of crop production in these areas of very erratic and variable rainfall. One problem is the risk of waterlogging in the 2:1 treatment and modifications are being made to the 1990/91 trials to try and overcome this.

Future Research

As the catchment basin water harvesting (CBWH) trials produce better and more reliable yields, the trials are being continued with some modifications. An additional treatment of 3:1 (catchment-to-crop area) has been added to try and capture more water in very dry seasons. To get over the waterlogging problem on the 2:1 and 3:1 treatments, an additional "buffer" plot has been added below the cropped plot. Excessive water on the cropped plot will be drained on to the buffer plot where fourwing saltbush will be planted. This drought-resistant forage shrub will utilise any surplus water drained off from above plot. The buffer plot is intended to overcome the reluctance of local farmers to drain off excessive water which stands on the lower parts of cropped fields and reduces yields.

Chapter 6

GERMPLASM GROUP

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Introduction

Almost 60% of the cultivated area of Balochistan depends wholly on the winter and monsoon rains, which are scanty and erratic. Due to the rapid increase in population, and the decreasing opportunities for intensive cropping in the limited irrigated areas, a well planned research strategy is essential to give best utilization of these rainfed areas. Water deficits severely limit crop yields in most years and low winter temperatures are also a severe constraint. Local crop varieties have a rather limited genetic potential for yield, disease resistance, and performance stability in this very variable, harsh environment. Improvements in yield and production can be sought by practices which increase the moisture supply, such as water harvesting, and by the selection and evaluation of improved varieties better adapted to drought and cold stresses and other environmental hazards.

A germplasm improvement program for wheat, barley, lentil and forage legumes has been conducted at AZRI in cooperation with ICARDA since 1982. Highlights of progress made during 1984-89 are described by Ali et al. (1989). A summary of the results obtained in the 1989/90 season is presented here; full details of all the trials, including tables of results, are given by Ahmad et al. (1990).

Objectives

The objectives of the AZRI germplasm program are twofold:

1. To select superior, disease-resistant crop species, genotypes and lines suitable for growth under non-irrigated conditions. Better genotypes of other crops would help farmers to diversify away from the wheat monocropping system which most farmers in highland Balochistan currently follow.

2. To investigate the potential for additional livestock feed production in the highlands, which could come from the introduction of forage crops, or from additional crop residues from food crops grown under rainfed conditions.

Methodology.

The crops currently being evaluated are bread wheat, barley, lentils and annual forage legumes (mainly vetches). Experiments on these crops were planted at four sites representative of typical cropping areas of highland Balochistan. The sites were:-

Quetta (Agr. Res. Inst.)	altitude	1690 m.	30° 07'N, 66° 58'E
Mehtar, Loralai	altitude	1340 m.	30° 24'N, 68° 58'E
Khan Mehtarzai	altitude	2250 m.	31° 00'N, 67° 45'E
Kalat	altitude	1850 m.	29° 07'N, 66° 24'E

The experiments were planted either in winter or spring following the practices of local farmers. The winter planting time - late September to end of October - was used to expose the material to low temperatures and to help select cold-tolerant, longer maturity genotypes. Spring planting - late January to end of February - was used to select material with a short maturity period without the need for enhanced cold tolerance.

An initial irrigation was used at Quetta, Loralai and Khan Mehtarzai for winter planting to ensure pre-winter emergence of the crop, as there was insufficient summer rainfall. For the spring planting, conserved moisture from the late winter rains was adequate to ensure emergence. Fertilizer rates were 60 kg N/ha and 60 kg P_2O_5/ha for the cereal crops, and 60 kg P_2O_5/ha plus Rhizobium leguminosarum inoculum was used for the legumes. The yield trials were planted in randomized complete blocks, each entry having six rows per plot, a row length of 5 m and a row spacing of 25 cm. The observation nurseries were a single 5 m row per entry. Harvesting of the trials took place between the end of May and the end of June. Only the central four rows were harvested from each six row plot to eliminate border effects; the TDM and seed yields were taken from these four rows. The crops were harvested manually and small threshing machines were used for grain separation.

Climatic conditions

Table 22 summarises the climatic conditions at three of the sites. The meteorological data from the fourth site, Loralai, have not been included because they were of poor quality. 1989/90 was a favourable agricultural year; more than 300 mm of well-distributed rains fell during the crop growth period at Quetta and Khan Mehtarzai. Early 1990 was also quite favourable for spring planted crops with more than 250 mm rain during the growth period of the spring planted crops at Quetta and Kalat. At Khan Mehtarzai heavy snow occurred during the winter and the crops remained under snow cover for two months. This retarded vegetative growth and delayed the maturation period of crops there. The absolute minimum air temperature in the winter months at Quetta and Khan

Table 22. Climatic data for three sites in highland Balochistan (1989/90).

	Quetta			Kalat			Khan Mehtarzai		
	Total rain-fall (mm)	Mean max. temp (°C)	Mean min. temp (°C)	Total rain-fall (mm)	Mean max. temp (°C)	Mean min. temp (°C)	Total rain-fall (mm)	Mean max. temp (°C)	Mean min. temp (°C)
July (1989)	6.0	33.2	18.4	38.0	30.3	18.3	14.8	28.8	16.4
August	1.6	33.2	16.1	0.3	32.8	15.3	0.0	29.5	14.2
September	0.0	31.1	10.1	0.0	29.3	9.5	0.0	28.8	10.0
October	0.0	25.4	3.8	0.3	25.4	3.9	0.0	23.9	2.5
November	4.6	18.8	1.5	2.8	18.1	0.8	0.0	17.1	-4.5
December	36.0	12.6	0.0	22.5	13.1	-3.0	31.6	9.8	-12.0
January	110.7	10.3	1.2	57.4	12.7	0.2	177.6	10.1	-3.0
February	110.6	11.6	1.2	126.7	11.8	-1.0	145.2	11.2	-2.0
March	30.8	17.6	2.0	59.9	16.4	0.0	65.6	13.2	1.5
April	1.1	24.4	7.6	14.8	23.0	7.0	56.0	23.2	7.3
May	0.0	31.8	12.1	4.4	31.0	12.0	0.0	30.3	10.0
Total	301.4			327.1			490.8		
Irrign.	50.0						30.0		
AMT(°C)[1]	-7.0			-7.2			-10.0		
NDBZ[2]	82			77			99		

[1]Absolute minimum temperature in season.
[2]Number of days with temperature below zero, 0°C, in season.

Mehtarzai was -7 and -10 °C, respectively. No severe cold damage was observed at Quetta but dessicating winds at this site during the grain formation period severely affected the grain setting of wheat, lentil and forage legumes, and as a result the seed of these crops was shrivelled and yields were low.

Trial Results

Bread wheat. There were four bread wheat trials:-

i) Bread Wheat Yield Trial Selection: winter 1988/89

ii) Bread Wheat Yield Trial Selection: spring 1988/89

iii) Bread Wheat Yield Trial: high altitude 1989/90, new material

iv) Bread Wheat Yield Trial: low rainfall 1989/90, new material

i). This trial included 26 genotypes of different origin and was planted in winter 1989/90 at Quetta, Loralai and Khan Mehtarzai. No severe cold damage was experienced but dessicating winds at Quetta during anthesis and grain formation shrivelled the seed of most entries and reduced kernel weights. Compared with the local check, entries WPT87 1511, WBWON84 111 and Gerek had higher grain yields at Quetta, while WBON84 111 and ICW81 1471 had higher grain yields at Loralai.

There was an epidemic of yellow rust (Puccinia striiformis) in 1989/90 and the local wheat landrace suffered very severe infection so that this season provided good natural screening conditions for selecting yellow rust resistant genotypes. Most of the exotic wheat lines were completely resistant, with the Turkish wheat Gerek being very winter-hardy as well as resistant to yellow rust. Its performance was encouraging during 1989/90 but further trials are required under heat and moisture stresses to determine its drought tolerance/resistance characteristics. The testing of all these selected lines will be continued.

ii). Spring-planting genotypes of bread wheat selected in 1988/89 were planted at Quetta and Kalat in spring, 1990. Although the grain yield of the exotic wheat lines in 1989/90 was not significantly higher than the checks, these lines performed better in 1988/89, a less favourable year for spring planted crops than 1989/90. Apparently, some of these exotic genotypes have enough drought tolerance/resistance to perform moderately well under moisture stress conditions. They will be further tested in widely contrasting environments to evaluate their genetic stability.

iii). This trial included 23 new genotypes of bread wheat for high elevation areas received from ICARDA/CIMMYT. It was planted only at Quetta, where it could be intensively monitored for cold and drought tolerance, growth habit, disease resistance, maturity period and yield potential. There was no severe cold damage but dessicating winds at the grain filling stage badly reduced seed sizes and weights. Line PWT189 5 gave the highest grain yield and it has been selected for further testing. The exotic wheat lines in this trial were resistant to yellow rust, but their grain yields were not significantly higher than the local check. Therefore in future more emphasis will be given to identifying a disease resistant genotype with a high yield potential which is at least as good as the local check in other respects.

iv). Twenty-three new genotypes were spring-planted at Quetta and Kalat to select short duration, heat and drought tolerant genotypes suitable for spring planting. Lines WOL88 14, WOL88 83 and WOL88 110 have been selected for further testing. These lines are erect and mature early, desirable characteristics for spring planting.

Barley. There were five barley trials:-

i) Barley Yield Trial Selection: winter 1988/89
ii) Barley Yield Trial Selection: spring 1988/89
iii) Barley Yield Trial Selection: 1986/87
iv) Barley Yield Trial: high altitude 1989/90, new material
v) Barley Yield Trial: low rainfall 1989/90, new material

i). Selected barley lines from the 1988/89 trials were planted at Quetta, Loralai and Khan Mehtarzai to evaluate desirable longer duration genotypes suitable for winter planting. For the Loralai area facultative genotypes were suitable with a low cold tolerance and no vernalization requirement. However, for Quetta and Khan Mehtarzai good cold tolerance and a need for vernalization were both essential to enable the material to pass the vegetative stage in winter in a dormant condition and start the reproductive phase after the end of winter. The Turkish barley Tokak had a high measure of winter hardiness but it matured later than local barley. Further large-scale evaluation and agronomic testing is required to confirm its adaptability in the highlands of Balochistan. After two years of testing these lines it has been found that some exotic entries are better adapted to the harsh Balochistan environment than local types. Two more years of testing will be needed for this material.

ii). During 1988/89, 13 short duration, spring barley lines were selected from ICARDA observation nurseries and yield trials. In 1989/90 these selected lines were sown at Quetta and Kalat in a season favourable for spring sown crops. The local barley landrace produced the most TDM at both sites and the highest grain yield at Quetta, but several of the exotic lines seemed to be more heat and drought tolerant, especially under terminal moisture stress at Kalat, and had less diseases. These promising exotic entries matured earlier than the local check and thus should have a better chance of escaping terminal drought at the reproductive stage. They will be tested again over the next two years to check their genetic stability.

iii). Four Syrian barley landraces were tested between 1986/87 and 1988/89 with spring planting at several sites under varying environmental stresses. These tests indicated that Wadi Hassa, Arabi Abiad and Arabi Aswad were well adapted to spring planting in highland Balochistan.

In trials in 1989/90, Wadi Hassa, Tadmor and Arabi Aswad gave higher grain yields at both sites than local barley. Arabi Abiad has already been selected for winter planting in highland Balochistan due to its better performance under moisture stress. This trial shows that it is equally suitable for spring planting in this area. Considering the different combinations of site and season, the selected lines Wadi Hassa, Arabi Aswad and Arabi Abiad have the genetic potential to do well when spring-planted in poor moisture conditions and are now receiving wider testing.

iv). This trial of high altitude material included 23 new genotypes from ICARDA which were planted in winter at Quetta. During the 1989/90 winter no severe cold damage was experienced. Five high yielding lines BYC88 1, BYC89 16, BYC89 17, BYC89 19 and BOC89 53 have been selected for further multi-location testing. The grain yields of these selected lines were 2586-3446 kg/ha compared with 1949 kg/ha from the local barley. All selected lines will be promoted to advanced yield trials during 1990/91 for testing at Quetta, Loralai and Khan Mehtarzai.

v). New material, including 23 exotic genotypes, was planted in spring at Quetta and Kalat for initial screening for short duration and heat and drought tolerance. Local barley produced the highest grain yield and TDM at Quetta. Line INBR89 12 gave significantly higher grain yields at Kalat when compared to the local check. Entries INBR89 12, BYL89 6, BYL89 15, BYL89 18 and BOL89 13 have been selected for further testing due to their good performance under moisture stress conditions at Kalat.

Lentils. Four lentil trials were carried out.

i) Lentil Yield Trials: selection 1988/89

ii) Lentil Yield Trials: winter and spring selection 1988/89

ii, a) Lentil Yield Trials: winter

ii, b) Lentil Yield Trials: spring

i). During 1988/89, 23 exotic, extra-large-seeded lines newly obtained from ICARDA, were planted in winter at Quetta, Loralai and Khan Mehtarzai. Based on overall performance, nine lines were selected for further testing during the next winter at all three sites.

In 1989/90 only two lines, ILL 5816 and 5842 equalled the local landrace and gave almost the same TDM production. The seed yields of three lines ILL 5668, 5699, 5988 at Quetta and three lines, ILL 5668, 5816, 5817 at Loralai, were not significantly different from the local control. No other entries were as good as the local check. Two lines, ILL 5816 and 5842, gave significantly higher seed yields than the local landrace at Khan Mehtarzai.

All the lines had been selected in 1988/89 on the basis of their good performance in that poor rainfall season. As dry years occur frequently in highland Balochistan selection during dry seasons is very appropriate for identifying drought tolerant genotypes. The genotypes which performed similarly to the best adapted local landrace in a comparatively good year also did significantly better in a poorer year. Two genotypes, ILL 5816 and 5842, appear to be suitable for poor and good environments. Large-seeded genotypes with similar yield to the local landrace are desirable due to their high market price and disease resistance.

ii). In 1988/89 three different sets of observation nurseries were received from ICARDA with a total of 89 test entries of different origin. They were sown at all three sites in winter and spring 1988/89. After being carefully assessed for cold tolerance, longer maturity period, disease resistance and higher yield potential, nine superior lines were selected for winter planting while six superior lines were isolated for spring planting because of their shorter maturity period. The shorter maturity lines completed their life-cycle within 130 days. All the selected lines were promoted to yield trials for further testing during 1989/90 at Quetta only; a seed shortage ruled out other sites.

ii, a). In the winter trial, TDM and seed yields did not differ significantly among the genotypes. Most of the selected lines have the same genetic background, performed similarly and were better than the local check in 1989/90.

ii, b). In the spring trial TDM and seed yield differences among the genotypes were significant, mainly because one line, ILL 4354 (Jordanian Local), was worse than all the others, including the local check. With the exception of line ILL 4354, all the other lines had similar productivity.

This material has not yet been exposed to a wide enough range of environments in highlands Balochistan because of a shortage of seed, and during 1990/91 it will be planted at all the experimental sites used for germplasm evaluation.

Forage legumes. Most of the work was done on woollypod vetch (<u>Vicia</u> <u>villosa</u> ssp. <u>dasycarpa</u>). Three trials and two nurseries were carried out.

i) Yield Trials: selections 1987/88:

ii) Yield Trials: selections 1988/89:

iii) Yield Trials: selections 1988/89:

iv) Observation Nurseries:

i). During 1987/88 eight lines of <u>Vicia</u> <u>sativa</u> were selected for further testing with two check entries, woollypod vetch (improved check) and local lentil, in a wide range of environments at three sites with two planting times. This was repeated during 1988/89 and again in 1989/90, with winter planting at Quetta, Loralai and Khan Mehtarzai. This trial will not be repeated; the final conclusions will be made on the overall performance of the genotypes over sites and years.

In 1989/90 V. sativa (Acc. 713, 715, 490) and woollypod vetch (Acc. 683) had a significantly higher TDM yield than the local control at Quetta. At Loralai no V. sativa line could compete with the improved or local checks which did not differ significantly. The local check was significantly better than all the other entries at Quetta and Loralai. One of the main reasons for the higher seed yield of the local control was that it matured 15 days earlier than the other lines which enabled it to escape from army-worm (Spodoptera sp.) attack at Loralai, and from hot, dry winds at Quetta near crop maturity. These problems badly affected the seed production of the other genotypes which matured later.

ii). After previous favourable tests of the performance of woollypod vetch eight improved lines of this forage were obtained from ICARDA for testing at different locations. Two check entries, the local lentil and woollypod vetch Acc. 683, were included in the trials for comparison. During 1989/90 the trial was conducted at Quetta, Loralai and Khan Mehtarzai, in winter only. At Quetta woollypod vetch Accs. 596, 800, 2558 and 683 all outyielded the local check but the seed yield was not significantly different within these four genotypes. At Khan Mehtarzai all the lines except two, Acc. 801 and 956, had significantly higher seed yield than the local control. At Loralai almost no seed yield was obtained from the trial because of heavy army-worm attack. The local check escaped attack as it matured 15 days earlier at this site than the other lines. This material will be tested once more at all three sites during 1990/91 so that the lines best suited to a wide range of areas of highland Balochistan can be selected.

iii). In 1988/89 18 different lines of Vicia sp. received from Iran were planted in single rows in the winter observation nursery at Quetta for initial cold screening. Due to limited seed the trial was planted at only one site. Judged on cold tolerance and other desirable characters, 11 lines were selected for promotion into yield trials for further testing.

In 1989/90, only two lines, Acc. 225006 and 225014, were equal to the local control in TDM production. Eight lines gave significantly higher seed yields than the local control. The selected material matures earlier than the local check so it can escape terminal stresses and insect infestations which frequently occurs at the later stages of crop maturity. These problems can badly affect the overall productivity of later maturing genotypes at high altitudes in Balochistan.

iv) Observation Nurseries. During 1989/90 118 different lines of Vicia spp. of different origin were received from Italy. Single row observation nurseries were planted in winter and spring at Quetta to select desirable genotypes for different planting times. On the basis of the desirable characteristics, 17 genotypes for winter and 12 for spring sowing were selected. These selected genotypes will be promoted into yield trials during 1990/91. Due to limited seed the trials will be planted initially at Quetta with two planting times. After seed multiplication these trials will be extended to other germplasm testing sites for further study.

References

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Chapter 7

STAFFING MATTERS, TRAINING, WORKSHOPS, CONSULTANCIES

New ICARDA Staff

Phase II of MART/AZR has three advisors as compared with five during Phase I. They are responsible for advising the Range and Livestock (R/L) groups, the Agronomy and Germplasm (A/G) groups and the Agricultural Economics (AE) group. The advisor to the R/L Group is Dr Euan F. Thomson who is also Team Leader. Before joining AZRI in July 1990 he had spent over 10 years at ICARDA headquarters in Syria as a livestock scientist. Dr Alister Allan, who started his duties in March 1990, is advisor to the A/G group. He has nearly 30 years of experience, mainly in Africa, but also spent three years as ICARDA's senior agronomist in Syria in 1979-82. In May 1990 Dr Abelardo Rodriguez joined the team as the agricultural economics advisor. He had previously worked as an assistant professor in the US and has particular strengths in quantitative econometric methodologies and the analysis of farm technologies under conditions of risk.

AZRI Staffing Difficulties

AZRI still suffers from acute under-staffing due to the absence of seven of its most able research staff on long-term training (LTT) during much of 1990. In October the situation improved somewhat in the R/L group with the return of the first AZRI scientist sponsored by the USAID MART project. However, the departure of two more staff on LTT at the end of 1990, and the fact that there are eight unfilled posts at AZRI, has reduced the A/G and AE groups to a staffing level that puts even priority 1 projects in jeopardy. The situation in the A/G groups may improve in 1991 with the return of one staff member from LTT, but the prognosis for the AE group remains bleak as filling positions is very difficult because of government recruitment restrictions, or because AZRI is unable to attract competent agricultural economists. This is true of other disciplines as well. Table 23 summarizes the present staffing situation in the various AZRI HQ disciplinary groups at the end of 1990. With seven staff on LTT and eight vacant positions there is almost a 50% deficit in staffing at AZRI.

Table 23. Staffing situation at AZRI HQ at the end of 1990.

Grade	Range/ Livestock	Agronomy/ Water harv.	Germplasm	Agric. Economics	Extension	Total
18 (SSO)	2	1	0	0	1	4
17 (SO)	2	3[2]	2	0	1	8
16 (ASO)	0	0	1	1	0	2
Ad-hoc	2	0	0	1[1]	0	3
LTT	2	2	2	1	0	7
Vacant	2	2	2	2	0	8
Total	10	8	7	5	2	32

[1]On short-term consultancy paid from MART/AZR budget.
[2]One of these posts still filled but likely to be vacated shortly.

Long-term Training

Dr Abdul Wahid Jasra, the first AZRI scientist sponsored under the USAID MART project to complete a PhD, returned in October 1990 from Oregon State University. A summary of his thesis is presented in Chapter 3 of this report.

Two AZRI SOs departed for long-term training at the end of 1990. Mr Khalid Mahmood, SO in the AE group, will start courses and research leading to a PhD or MS in the Department of Agricultural Economics at Oaklahoma State University, sponsored by the USAID MART project. Mr Atiq-ur-Rehman, SO in the R/L group, will start courses and research leading to a PhD degree at the University of Western Australia, Perth, sponsored by the Australian Development Assistance Bureau. He will conduct research on the feeding value of fourwing saltbush.

Short-term Training

Mr Muhammed Aslam, SO in the Germplasm group, returned in December from a four month course on "nitrogen, irrigation and crop management" held at the University of Idaho.

Workshops

In May 1990 AZRI staff and two of the ICARDA advisors attended the USAID sponsored seminar on "Agricultural Sustainability: Provincial Perceptions in Pakistan" held at the Serena Hotel, Quetta. Such seminars were held in the four provinces of Pakistan and they will be followed by a national seminar in March 1991. Dr B. Roidar Khan chaired the discussion group on "Livestock Production and Range Management" issues.

On 1/2 October 1990 a workshop on water harvesting for provincial directors of agriculture was held at AZRI at the request of the Balochistan Department of Agriculture. It consisted of one day of presentations by AZRI scientists and the ICARDA Agronomy advisor, and one day of field trips to the water harvesting trials.

Seminars

A seminar on "Water resources development and its management in arid areas" was held at the Serena Hotel, Quetta from 6-8 October 1990. The seminar, organized by the Pakistan Council for Research in Water Resources, was sponsored by USAID and supported by AZRI and ICARDA from MART/AZR funds. Two papers by AZRI staff and one by Dr Rodriguez, were presented (see publication list in Annex 2).

The monthly seminar series, open to AZRI and staff of provincial departments, was reinstated and included the following speakers and titles:

September: Dr A. Rodriguez (ICARDA Agricultural Economics advisor): rainfed crop and livestock production in highland Balochistan: a modelling approach proposal.

October: Mr Qazi Bashir Ahmed (ARI Sariab): surveys on wheat and potato production in Balochistan.

November: Dr A.W. Jasra (AZRI R/L group): studies on the dietary composition and nutrient status of sheep and goats grazing two rangeland types in Balochistan.

December: Dr M. Selim (Balochistan Forestry Department): studies on *C. aucheri* and *C. shoenanthus*, two perennial grasses from Balochistan.

Consultancies

Dr David Rees, Agronomy advisor during phase I of the MART/AZR project, returned for a five week consultancy starting in mid-November. The main aim of the consultancy was to present refresher courses on the use of micro-computers and to promote continuity of the agronomic and water-harvesting research started during Phase I. The following specific tasks were accomplished:

1. Follow-up courses were held on computer programs for management, analysis and presentation of agricultural research data (DOS, NORTON, MSTATC, PLOTIT, LOTUS 123).
2. Operation of rainfall analysis and runoff prediction programs developed at AZRI were reviewed.
3. Physical and biological components of a model of micro-catchment water harvesting in highland Balochistan were discussed in detail and example data sets provided.
4. Agronomic and meteorological computer data files from 1985 to 1989 were reviewed with AZRI staff.
5. Estimation and utilization of statistical relations between different estimates of crop water receipt and yield were reviewed.
6. The use of neutron probes in soil water monitoring for water harvesting experiments was reviewed, a potential monitoring scheme outlined, and a data base management program for this scheme developed, using Lotus 123.
7. The operation and programing of the automatic weather stations, and the operation of a data base management program designed for AZRI's automatic weather stations, were reviewed.
8. The need to investigate the possibilities of developing research programs for the improvement of other, traditional water harvesting systems in Balochistan and Pakistan, in addition to the existing program, were outlined, and the tentative terms of reference for a preliminary short-term consultancy for an arid-lands hydrologist, presented.

Annex 1. Papers, MART/AZR Research Reports and Theses Published in 1990

(The 1986, 1987, 1988 and 1989 MART/AZR Annual Reports are published as ICARDA Reports Nos ICARDA-110, ICARDA-127, ICARDA-138 and ICARDA-158).

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Keatinge, J.D.H., A. Ali, B. Roidar Khan and S. Ahmad. 1990. Germplasm evaluation of annual sown forages under environmental conditions marginal for crop growth in the highlands of West Asia. Journal of Agronomy and Crop Science. In press.

Rees, D.J., Samiullah, A., Rehman, F. Kidd, C.H.R., Keatinge, J.D.H. and Raza, S.H. 1990. Precipitation and temperature regimes in upland Balochistan: their influence on rain-fed crop production. Agricultural and Forest Meteorology 52: 381-396.

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Rodriguez, A. 1990. Rainfed plant and livestock production in highland Balochistan: a modelling approach proposal. In: proceedings of the National Seminar on Water Resources Development and its Management in Arid Areas. Pakistan Council of Research in Water Resources, Water Resources Research Centre, Quetta. Pages 353-360.

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MART/AZR Research Reports

Buzdar, N., J.D.H. Keatinge, G., F. Sabir, M. Afzal, N.A. Shah and A. Ali. 1989. Lentil Production in Highland Balochistan: Current Status. MART/AZR

Research Report No 55.

Ali, A., J.D.H. Keatinge, B. Roidar Khan and S. Ahmad. 1990. Germplasm Evaluation of Lentil Lines for the Arid Highlands of West Asia. MART/AZR Research Report No 56.

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Annex 2. AZRI Headquarters Scientific and ICARDA MART/AZR Staff (on 31.12.90)

AZRI Staff

Director AZRI	Bakht Roidar Khan (PSO[1], PhD)
Water Harvesting	S. Hassan Raza (SSO[2], Deputy Director) Sher Mehmood (SO[3]) Muhammad Islam (SO) Mohammed Aslam (SO) M. Arshad Ali (SO, LTT[4]) Z. Ali Qureshi (SO, LTT) Ahmad Samiullah (SO, LTT)
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Range/Livestock Group	Shahid Rafique (SSO, PhD) A. Wahid Jasra (SSO, PhD) Javed Afzal (SO) Muhammad Munir (SO) Muhammed Asghar (SO) Atiq-ur-Rehman (SO, LTT) Abid Hussan (SO, ad-hoc appointee) K. Nasir Mahmood (SO, LTT)
Economics Group	Khalid Mahmood (SO, LTT) Muhammed Afzal (ASO) Mohammad Jamil (SO, ad-hoc appointee) Imran Ali (short-term consultant) Nisar Ali Shah (grade 11)
Extension Group	M. Bilal Ahmad Chowdry (SO) Mohammad Aslam

[1]PSO = Principal scientific officer, [2]Senior scientific officer, [3]Scientific officer, [4]Long-term trainee (PhD/MS), [5]Assistant s.o.

ICARDA MART/AZR Staff

Euan F. Thomson	Range/Livestock Advisor, Team Leader
Alister Y. Allan	Water harvesting/Agronomy/Germplasm Advisor
Abelardo Rodriguez	Agricultural Economics Advisor
Pesi R. Amaria	Office Manager and Financial Administrator
M. Zafar Jalil	Assistant Financial Administrator
Katherine Samuel	Secretary
Aslam James	Driver
Nazir Patrick	Driver
Sharafat Barkat	Driver
Eric Masih	Driver
Yousaf John	Driver