PN-ABZ-722

Highland Regional Program

The MART/AZR Project
Pakistan

1992

Annual Report

Arid Zone Research Institute
Quetta, Pakistan

International Center for Agricultural
Research in the Dry Areas
Aleppo, Syria

PN ABU-722

HIGH ELEVATION RESEARCH IN PAKISTAN
THE MART/AZR PROJECT

ANNUAL REPORT 1992

Arid Zone Research Institute (AZRI)
PO Box 63, Quetta, Pakistan

and

International Center for Agricultural Research in the Dry Areas
(ICARDA), PO Box 362, Quetta, Pakistan

(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)

a

Acknowledgement

Phase II of the MART/AZR project has now completed three years. The project, which started in mid-1985 with support from the USAID Mission to Pakistan, is helping AZRI become the principal Pakistani federal research institute focusing on sustainable pastoral and rainfed farming systems for the arid areas of Pakistan. Nearly all the project efforts are directed at the highland areas of Balochistan (Figure 1), although AZRI has modest research activities at sub-stations in each of the other provinces of Pakistan. ICARDA has been the executive agency of the project since 1985.

One of the most significant changes affecting MART/AZR during 1992 was the reduction in the number of Quetta based ICARDA scientists from three to one. Dr Alister Allen, who was responsible for advising staff in the Agronomy and Germplasm Sections, completed his two year contract on March 31. In mid-July Dr Abelardo Rodríguez transferred to the Farm Resource Management Program at ICARDA headquarters after spending 26 months in Quetta advising staff in the Economics Section. The efforts they put into assisting AZRI scientists in the respective sections are much appreciated, as is the support they gave to the ICARDA Team Leader. Dr Rodríguez is also thanked for making a major contribution to Chapter 4 of this report.

Equally significant is the increasing contribution of AZRI staff to the preparation of this Annual Report. Indeed, they are increasingly responsible for the research reported and their efforts are gratefully acknowledged.

Particular thanks are due to the Chairman of PARC, Dr Zafar Altaf, and to the PARC Member Natural Resources, Dr Sulaiman Hamid, who both provided continuous support and encouragement to AZRI during 1992.

Thanks are also extended to the USAID Mission to Pakistan for its support, and in particular to Dr Ron Senykoff, Dr Mohammad Khalid and Dr Muhammad Saeed who are always ready and willing to deal with the frequent requests from Quetta.

During 1992, ICARDA staff in the Quetta office continued to show a commendable degree of devotion to the project, especially Mr Pesi Amaria who is responsible for all financial matters, and the day-to-day office management. He was also totally incharge of the office each time the ICARDA Team Leader was absent from Quetta.

March 1993

Euan F. Thomson
ICARDA Team Leader,
MART/AZR Chief of Party

Bakht Roidar Khan
Director, AZRI

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

Map of the Highland Areas of Balochistan

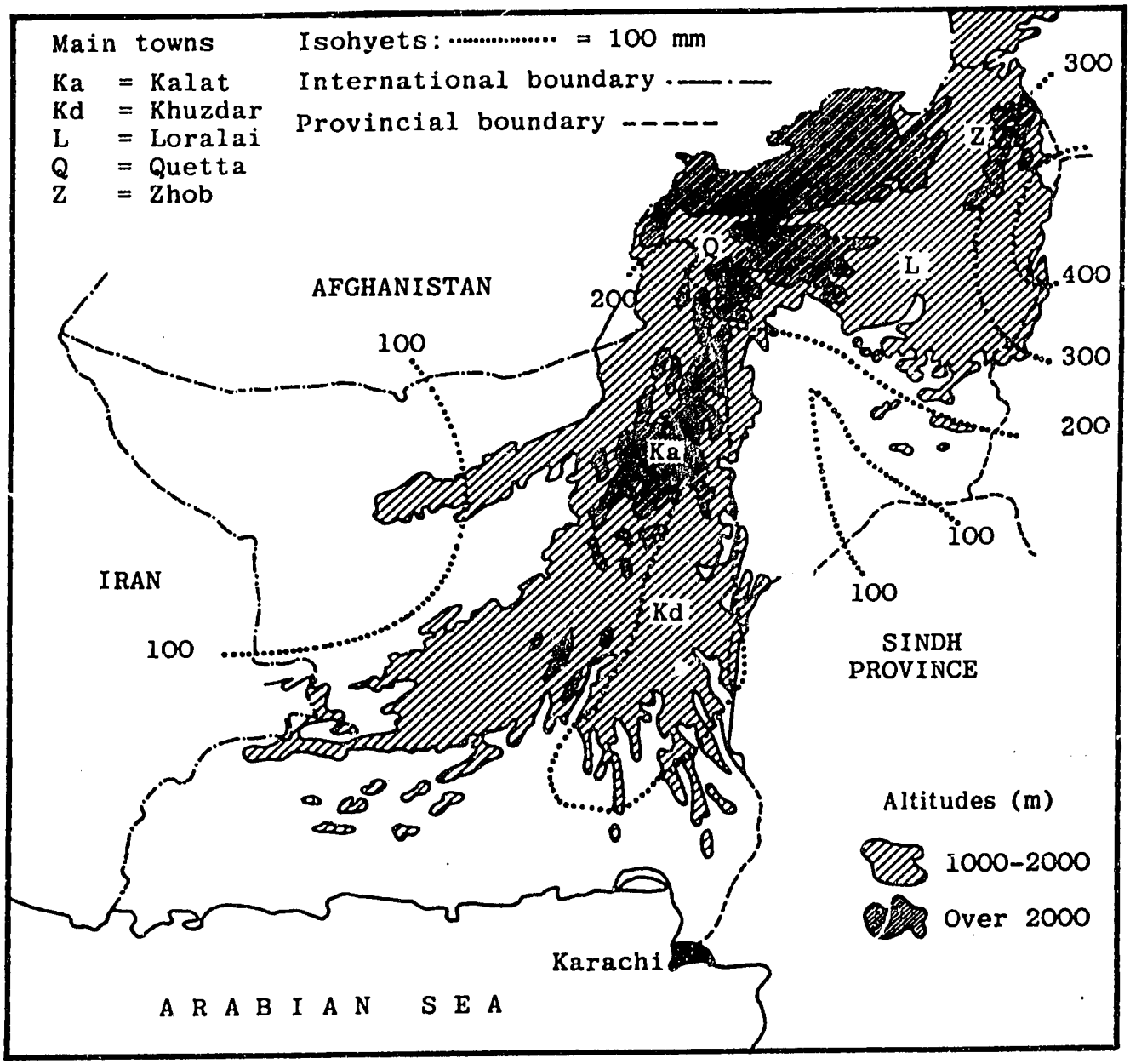


Figure 1. Map of the Pakistani province of Balochistan, showing areas over 1000 and 2000 m altitude, isohyets and main towns.

Table of Contents

	Page
Acknowledgement	i
Map of the Highland Areas of Balochistan	ii
Table of Contents	iii
List of Common Abbreviations	iv
AZRI Research Sites	v
Map showing AZRI Research Sites in Highland Balochistan	vi
Chapter 1: Project Goal, Purposes and Activities	1
Chapter 2: Research on Fourwing Saltbush	7
Chapter 3: Small Ruminant Research	20
Chapter 4: Agricultural Economics Research	23
Chapter 5: Water Harvesting and Agronomy Research	35
Chapter 6: Germplasm Research	40
Chapter 7: Staffing Matters, Collaboration, Training, Workshops	46
Annex 1: Journal papers, and MART/AZR Research and Other Reports	52
Annex 2: AZRI Headquarters Scientific and ICARDA MART/AZR Staff	54

List of Common Abbreviations

AZRI	Arid Zone Research Institute
BOSTID	Board of Science and Technology for International Development, National Research Council, Washington
CBWH	Catchment-basin water-harvesting
CV	Coefficient of variation (percent), which is the standard deviation as percentage of the mean
DM	Dry matter (percent)
DMD	Dry matter digestibility (percent)
DMI	Dry matter intake (g per day)
FAO	Food and Agriculture Organization of the United Nations
FWSB	Fourwing saltbush (*Atriplex canescens*)
GOB	Government of Balochistan
GOP	Government of Pakistan
ICARDA	International Center for Agricultural Research in the Dry Areas
LSD	Least significant difference
MART	Management of Agricultural Research and Technology
MART/AZR	Management of Agricultural Research and Technology - Arid Zone Research (component)
ns	Non-significant (P>0.05)
OMD	Organic matter digestibility (percent)
OMI	Organic matter intake (g per day)
PARC	Pakistani Agricultural Research Council
SD	Standard deviation
SEM	Standard error of mean
SED	Standard error of difference
TDM	Total dry matter (kg per ha)
USAID	United States Agency for International Development

AZRI Research Sites

AZRI Research Station, Quetta
The main station of AZRI, situated at the top of Brewery Road in Quetta, comprises an office and laboratory block, a colony for resident AZRI staff, storage sheds, the Animal Nutrition Unit, and 30 ha of land. Much of the land is gravelly and is used for studies on fourwing saltbush (FWSB). A small area is used for germplasm evaluation and for seed multiplication.

Tomagh Range/Livestock Station
This station is situated near Sanjavi, a small town about 60 km west of Loralai in Loralai Province. It uses range which is adjacent to a 4,000 ha forest reserve established in 1906 by the Forest Department. There are simple buildings, including accommodation for resident chowkidars and visitors, animal yards and pens, feed and materials storage and a nursery for about 10,000 FWSB seedlings. About 100 Harnai sheep and 10 goats are kept at the station which is 4-5 hours drive from Quetta. The ranges are dominated by the warm season perennial bunch grasses *Chrysopogon aucheri* and *Cymbopogon schoenanthus*. The annual rainfall is about 250 mm, with some 40 percent being received during the summer monsoon in July and August.

Zarchi Range/Livestock Station
This station is situated about 25 km west of Kalat, in Kalat Province. The station has simple buildings, including accommodation for resident chowkidars and visitors, animal yards and pens, and feed and materials storage. About 100 Balochi sheep and 10 goats are kept at the station which is 3 hours drive from Quetta. The surrounding shrublands are dominated by *Artemisia maritima* (this has now been judged to be *A. herba-alba*). The annual rainfall in the area is about 200 mm, with about 90 percent falling in winter and spring.

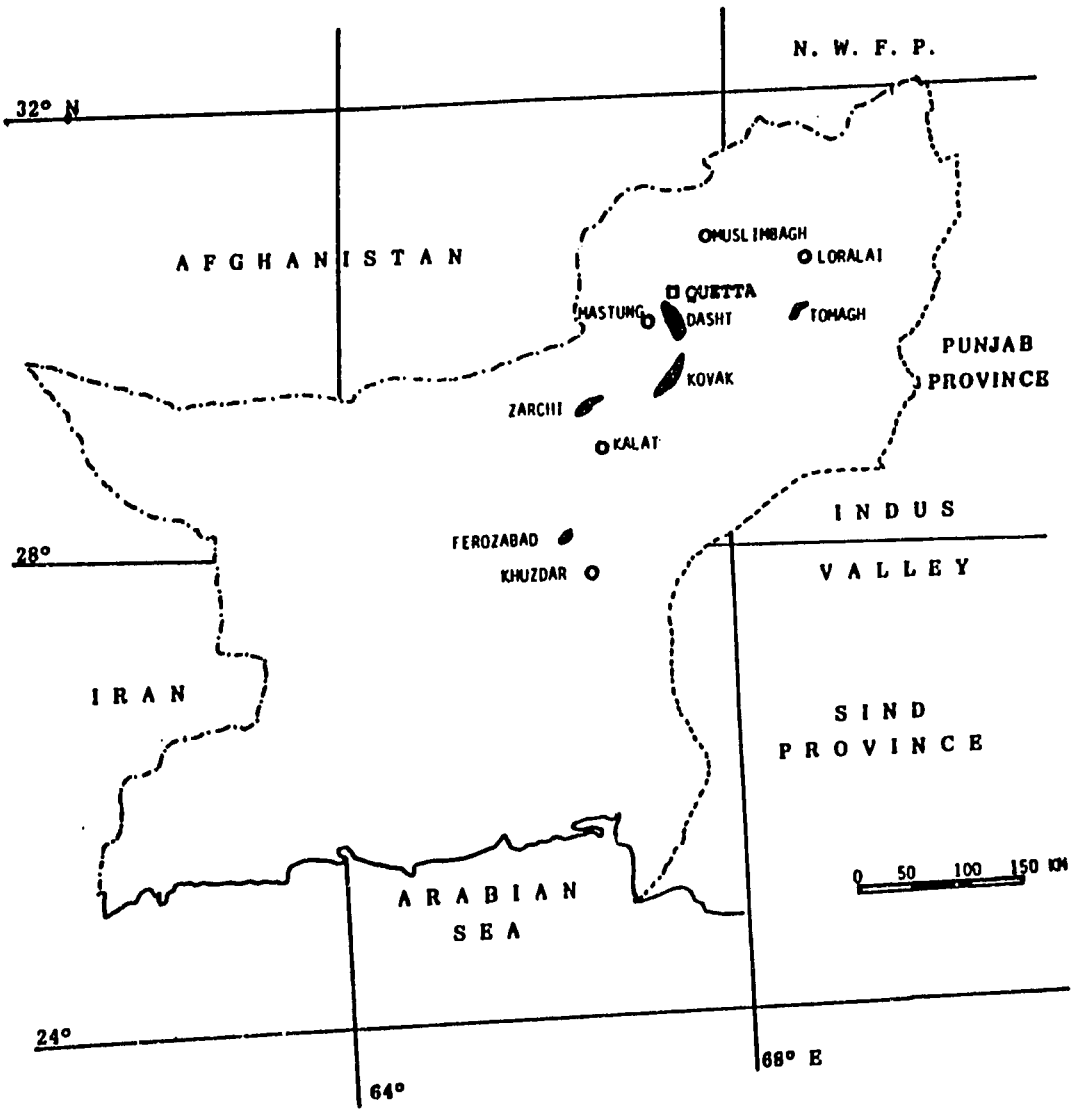
Mastung Station
AZRI has a 45 ha block of land belonging to the Department of Agriculture at Mastung, 50 km south of Quetta. The site is used for studies on strip-cropping, water-harvesting and for seed multiplication.

Karkhasa National Park
Karkhasa National Park is a valley close to AZRI station controlled by the Balochistan Forestry Department. It has been protected from grazing for about 11 years and is used for studies on FWSB.

Catchment Basin Water-harvesting/Contour Strip-cropping FWSB Trial Sites
Kolpur, Spezand, Dasht and Hazargangi (all in Quetta valley), Mastung, Kili Wahar (20 km east of Loralai), Kila Saifullah (near Muslimbagh).

Germplasm sites
Agricultural Research Station (ARI) at Sariab (Quetta), Kalat, Khan Mehtarzai (near Muslimbach), Mehtar (east of Loralai).

Map showing AZRI Research Sites in Highland Balochistan



Chapter 1

PROJECT GOAL, PURPOSES and ACTIVITIES

This chapter aims to provide the framework to understand and assess the project activities which are outlined in the following chapters. The goal and purposes of the MART project are presented in the first two sections and these are followed by a section on the specific activities of the Arid Zone Research (AZR) component of MART which are being addressed at AZRI. The final sections span a number of issues, including the BOSTID grant awards and topics concerning specific activities.

Project Goal

The MART Project goal is to "improve the incomes of resource poor farmers, sustain an increase in food and fibre production, and conserve the natural resource base" (see amended MART Project Document for phase II, July 1990).

Project Purposes

The MART project purpose is to:

1. "develop and disseminate improved technology and information through key research institutions"; and

2. "foster a collaborative relationship whereby research institutes serve private agri-business and farmers and use the private sector to disseminate marketable, improved technologies".

Thus, the main change in focus of phase II over phase I of the MART project is the inclusion of agri-business in the research process in such a way that public sector research institutions respond to the demands of the private sector, as well as to farmers and government agencies. This change in project focus poses a problem for AZRI since there is only an embryonic agri-business sector in Balochistan. This became clear in the agri-business consultancy which ICARDA commissioned in June 1991 (AZRI/ICARDA, 1992, pages 4 and 58-60).

Project Activities

A further narrowing of the focus of the research at AZRI was an important goal during 1992. This goal was pursued by getting staff to draft research protocols during the period March and April. They were reviewed at the annual AZRI/ICARDA Planning Meeting held in Quetta on May 11, and again at the first AZRI/NARC coordination meeting, held at NARC on May 31. Representatives from the GOB departments of Agriculture, Livestock and Forestry were invited to attend these meetings, as well as experts from other bilateral projects, such as the integrated FAO/UNDP Range-Livestock Project.

Efforts also continued to shift the focus of AZRI research from technology identification and development towards on-farm testing of technologies with farmer participation. This is proving a difficult task since most staff at AZRI

are trained in disciplinary fields[1]. However, **the shift is essential since technologies that are not acceptable to farmers are not adopted. This makes much research academic, a luxury institutes like AZRI cannot afford to indulge in.** Indeed, AZRI, like most research institutes, has almost no budget of its own to cover research operating costs. This makes it imperative to emphasize adaptive research which is needed to make an impact on farming and to convince local officials that the research at AZRI is benefiting the province.

The narrowed research activities of the five different Sections at AZRI are given below. They are modified versions of the activities shown in the MART/AZR project document, Phase II.

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

a. growing the forage shrub fourwing saltbush as a forage reserve on land owned by farmers and marginal for crop production[2]. In these studies, land treatment practices are being tested which improve the capture and retention of precipitation in the root zone, thus enhancing plant establishment and productivity. These practices include ripping, contouring, micro-catchment formation and other types of run-off capture. Grazing studies are also being conducted which aim to define the optimum grazing management of the shrub.

b. Studies on the effects of strategic supplementation of sheep grazing range on animal productivity throughout the annual production cycle. The relationships between different and variable sources of feed and key animal production parameters are being determined.

The activities of the **Agronomy/Extension and Germplasm Sections** include:

a. Examination of water-harvesting techniques which aim to make better use of low and erratic rainfall. This includes the study of catchment-basin water-harvesting and contour strip-cropping.

b. Studies on integrated annual crop/perennial forage shrub production practices (inter-cropping), with water-harvesting, to maximize forage production from scarce rainfall.

c. Establishment of saltbush on farmers' land to demonstrate the value of forage reserves.

d. Studies on the screening, selection, seed multiplication and release of promising germplasm of forage and dual-purpose crop species (barley, vetch, lentil, wheat, etc.) for food and feed production.

---

[1]The following is taken verbatim from the 1991 MART/AZR Annual Report. "Considerable efforts have been made during 1991 to increase the "downstream" research at AZRI. Such research, often referred to as applied or adaptive research, involves the on-farm testing of technologies with full participation of farmers. However, progress in this respect, particularly increasing the participation of farmers, has been slow. Several reasons for this are suggested. First, the Extension Section consists of only one person. Second, most AZRI scientists do not come from an agricultural background. Third, the classical discipline and commodity approach to research is still prevalent among AZRI scientists. Fourth, farmers are in other areas with their animals. And fifth, farmers are working elsewhere. It will require firm leadership to change this attitude in scientists who were trained in the classical discipline oriented approach to agricultural research. The long-term training program is exacerbating the problem rather than alleviating it. It can only be overcome by adding a strong systems component to long-term training courses which put emphasis on the need for inter-disciplinarity, downstream research and involvement of the farmer in the research process. Regrettably most universities in both developed and developing countries still do not recognize this need."

[2]This is an important point. There is some hope of the shrubs being protected from marauding and even communal village flocks if they are growing on land that is owned by a farmer. Also, it is now fairly well established that saltbush should be grown on marginal land where there is little competition from the native range plants. Marginal land is here defined as land that is owned by a farmer and could be used for growing crops. However, crops are seldom grown on it since the soil is somewhat stony and shallow, there is little opportunity for water-harvesting or it is far from the village.

The activities of the Agricultural Economics Section include studies on:

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 and flock production efficiency and minimize the long-term risks experienced by communities supported largely by agriculture.

b. Socio-economic constraints to livestock production in the upland areas of Pakistan, such as livestock marketing. This research includes surveys of 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.

c. Determining whether improved methods of water-harvesting can be profitable and can assist in ensuring higher and more stable returns to investment by farmers than the current subsistence systems.

d. Evaluating farmers' perceptions of alternative technologies, in particular water-harvesting and forage reserves.

e. Developing a model to measure the impact of AZRI technologies on productivity at the farm and provincial level and to help prioritize research activities according to the potential benefit to farm productivity and income stability.

BOSTID/PEP Grants

The two BOSTID grants awarded to AZRI as part of the MART project started in April 1992. They are administered by the Board of Science and Technology for International Development (BOSTID), itself part of the National Research Council in Washington. The grants, which are from $60,000 to $70,000 over two years, are for research on problems facing stressed lands. Project proposals were submitted in October 1990 and later refereed by a joint PARC/BOSTID committee and specialists from universities and research stations in the USA. The committee sat in Islamabad in August 1991 and out of a total of eight awards made on a nationwide basis during the first allocation, two of AZRI's three proposals were selected for funding. About 25 grants were eventually awarded, and the only two in Balochistan are at AZRI. The titles of the two proposals are "Use of water harvesting to enhance crop production in arid and semi-arid areas of Pakistan" and "Can the productivity of sheep be increased by better management of indigenous breeds in highland Balochistan?". The two projects are being run by principal and co-principal investigators, to a large degree independently of the ICARDA project Director. Several visits have already been made to the projects by reviewers from US universities and research institutes.

In December AZRI was awarded Rs1.6 million under the Productivity Enhancement Program (PEP) of PARC. The award to AZRI is part of a project aiming to enhance the productivity of stressed lands. The project will help expand the saltbush nursery at AZRI to 200,000 plants and in 1993 an assessment will be made of the value of planting saltbush on saline areas close to Quetta. The project lasts two years.

Livestock and Range Management

In terms of sustainability and importance to the economy of Balochistan, the research on these subjects should be given the highest priority at AZRI. Such research is perhaps the most complex to implement and the most long-term of AZRI's activities. Decades rather than years are needed to show impact.

The shortage of staff in the Range Section has meant that it is only able to focus on saltbush research. A special effort was made to collect all the data on this forage shrub from the previous three years' research and to make a preliminary statistical analysis and interpretation of the results. These are presented in Chapter 2.

As 1992 progressed, the livestock research was less constrained by a shortage of staff due to the addition of staff on contract and funded from the BOSTID grant. Only a few of the results from the Section for 1992 (see Chapter 3) are reported this year as these will be presented at greater length in the 1993 annual report.

Socio-economic studies

Research on problems of agricultural production and marketing in arid zones is one of the specific research areas of the MART project. The Economics Section has responded by conducting a series of surveys on the marketing of small ruminants (see Chapter 4) and skins (see 1991 MART/AZR Annual Report, and Rodríguez *et al.*, 1992). It has become abundantly clear that these are complex operations involving many agents who link the producer to the consumer, and that the processing of small ruminants is conducted under primitive conditions.

Studies on the economic viability of water-harvesting and seasonal price indices of agricultural commodities have reached an advanced stage. The latter study will provide key information for the planning of production and marketing.

Water-harvesting

The potential of water-harvesting as a technology to increase crop yields is a controversial topic and research efforts have been frustrated by the inability to harvest the same set of plots each year. This is partly due to large seasonal variability of rainfall but also because of technical problems such as poor germination and flooding of plots (see Chapter 5). The catchment-basin water-harvesting (CBWH) system has now been investigated for six years and during 1993 all the results will be critically reviewed, analysed and reported. The timing is appropriate since the BOSTID supported project on water-harvesting has already started and will end in April 1994. By that time it should be possible to make fairly clear statements about the biological and economic potential of the technology.

Doubts still remain whether or not farmers are likely to adopt the water-harvesting technology in its present form. For this reason two new initiatives were taken in 1992. One was to study more systematically farmers' perceptions of water-harvesting (Chapter 4, pages 31-32), and the other was to investigate alternative methods of water-harvesting. Trials investigating strip cropping were established late in December 1992 at Mastung, Dasht and Kolpur, following the recommendations of Dr Oweis, the ICARDA water-harvesting specialist who visited AZRI in November. A pilot row-spacing trial was also established at Mastung in early 1993 since this may be the cheapest way to increase crop yields in regions where rainfall is low. This would make it more attractive to farmers who are reticent about CBWH, and probably strip-cropping, since both involve set-up costs arising from land-levelling, and surface sealing in the case of CBWH.

Germplasm Improvement

The focus of the Germplasm Section has changed quite substantially with the dramatic expansion of the area of seed multiplication of promising lines of germplasm selected at AZRI over several years (Chapter 6). It is anticipated that seed multiplication and variety registration will receive even more emphasis in 1993, with less importance being given to screening of new material.

For a third year rainfall was abundant and there was a high incidence of yellow rust on the local landrace of wheat but little on the selected genotypes, seed of which is being increased. This is a very encouraging achievement.

Staffing Levels

The capability and reputation of a research institute is largely dependent on its cadre of scientists and on their output and achievements. This cadre continued to strengthen in 1992 with the influx of new staff and the transfer out of other staff who had been at AZRI for many years. Details of the changes are shown in Chapter 7, and Figure 1.2 compares the strengths of the various AZRI Sections in the past and projects them into the future.

The picture is still similar to that one year ago regarding the Agronomy and Germplasm Sections, which are still numerically the strongest, and the Range and Extension Sections, which are still relatively weak. The Livestock and Economics Sections will get stronger in 1993 if the one staff member currently on a PARC contract in each Section gets a regular contract. (At the time of writing this report the Extension Section had been strengthened due to the addition of one PSO (previously the PARC Provincial Coordinator) and the transfer of another staff member from the Range Section.) It will be essential to strengthen, in particular, the Range Section in 1993 since this is arguably the most important one at AZRI. This could be achieved by giving one staff member in the Germplasm Section responsibility for studies on the collection, conservation and use of indigenous range plants.

The Future

The most important issues still facing AZRI are: strengthening of the scientific staffing even more, development of collaborative projects between AZRI and NARC scientists, and an increase in the AZRI operating budget.

Still more emphasis will need to be given to collaboration between staff at AZRI and NARC. It is a rational goal since AZRI has many research issues that need to be addressed but it is unjustifiable to have resident scientific expertise when NARC has comparative advantages in this respect. Possible areas of collaboration are shown in Chapter 7 (page 47).

At the international level, efforts will continue to strengthen research linkages between AZRI and ICARDA headquarters in Syria and to build AZRI into the ICARDA Highlands Regional Program that covers Turkey, Iran, Afghanistan and highland Balochistan.

There is now one full cropping season until the end of the MART/AZR project in August 1994. During this time special attention will be given to studying the

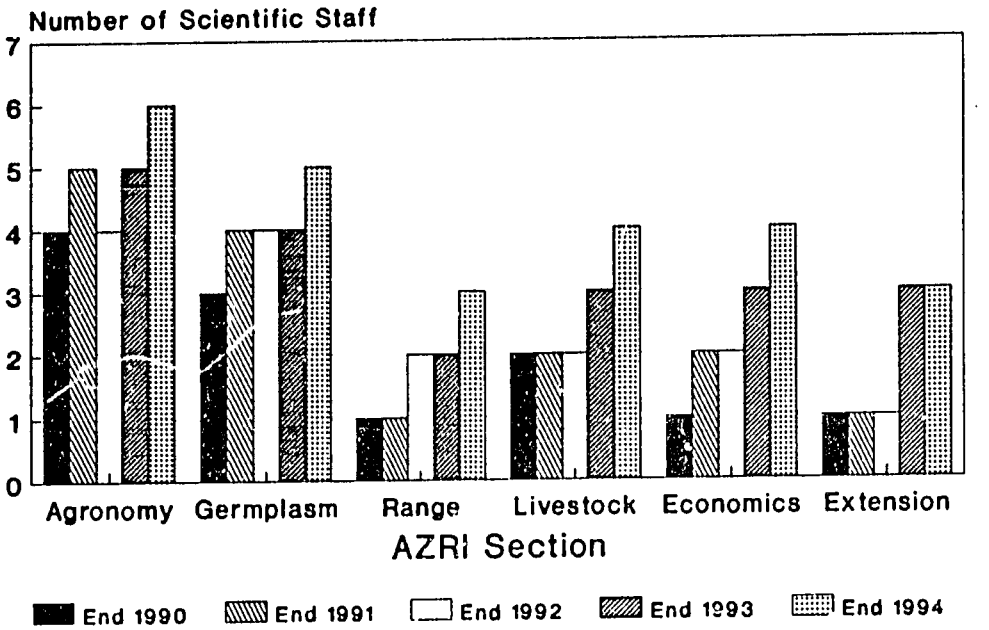


Figure 1.2. AZRI scientific staff by Section at the end of 1990, 1991 and 1992, and projected to the end of 1993 and 1994 when all long-term MART/AZR trainees will have returned. Ad-hoc appointees and staff on PARC contracts are assumed to have become regular staff in 1993 and 1994. Staff funded under BOSTID and PEP are excluded.

perceptions of farmers concerning technologies tested during the last six years, measuring their potential impact on the farm economy, and assessing the likelihood that the technologies will be adopted.

ICARDA Advisor: Euan F. Thomson

References

AZRI/ICARDA (Arid Zone Research Institute/International Center for Agricultural Research in the Dry Areas). 1992. The MART/AZR Project Annual Report 1991. AZRI/ICARDA, Quetta, Pakistan. pp. 63.

Rodríguez, A. I. Ali Shah, M. Afzal and N.A. Shah. 1992. Marketing of Goat and Sheep Skin in Highland Balochistan. MART/AZR Project Research Report No. 76. ICARDA Quetta.

Chapter 2

RESEARCH ON FOURWING SALTBUSH

Introduction

Highland Balochistan is generally defined as those areas above 1000 m altitude (Figure 1, page ii). The climate is harsh, with annual rainfall increasing from 200 mm at the southern end of the highlands to over 400 mm in the north-east of the province. Most of this rain falls in winter, although, in the north, up to 40 percent can fall as monsoon rain in summer. Winters are cold with mean minimum temperatures in January close to zero, although absolute minimum temperatures can fall to -15°C. Since 1985, the Range Section at the Arid Zone Research Institute (AZRI) in Quetta has focused on range vegetation surveys, and on assessing the potential of exotic grasses and fourwing saltbush (*Atriplex canescens*). 1992 has seen a narrowing of the focus of the Section, partly because it only has three scientific officers and partly because fourwing saltbush appears to be the most promising technology emerging from the research efforts of the Section.

The research on exotic grasses has completely stopped, since they showed only a limited adaptation to the conditions of highland Balochistan, with the exception of weeping lovegrass (*Eragrostis curvula*), which has shown good persistence at Tomagh due to the summer rainfall at that site (AZRI/ICARDA, 1991). Furthermore, it seems most unlikely that farmers in Balochistan will reseed rangeland because of the cost, the need to import seed, the lack of control over marauding flocks and the management requirements needed to ensure good persistence of exotic grasses.

It is also emerging that fourwing saltbush, a perennial halophytic chenopod native to the arid south-western states of the USA, is well suited for growing on land marginal for cultivation, where there is some soil but poor plant cover. The former is important for the storage of water, which helps the seedlings survive through the first summer, and the latter is necessary since competition from native shrubs appears to severely reduce growth of saltbush. This information is being taken into account when selecting sites for demonstrating forage reserves.

It should not need mentioning that the on-farm testing of saltbush with full participation of farmers is an essential part of the research process and such activities need to be accelerated at AZRI. A forage reserve was established near Miangundi in March 1992 and two further sites will be added in 1993. This aspect of the research is described on page 16 of this chapter.

Focusing on just one species to provide feed from rangeland and land marginal for cultivation has obvious weaknesses. For this reason, another perennial forage shrub, *Salsola vermiculata*, which can be propagated direct from seed is being multiplied in the AZRI nursery from seed provided by the Pasture, Forage and Livestock Program of ICARDA in the spring 1992. Research is likely to begin in 1993, when enough seed is available.

Sarwat N. Mirza: Head, AZRI Range Section

Euan F. Thomson: ICARDA Advisor

Benefits of fertilizers, manure and micro-basin water-harvesting (Protocol R02)

Plant density, the possible benefits of fertilizer application and manure, and two different methods of micro-basin water-harvesting, are being investigated in this trial. It was initiated with the planting of nine month-old seedlings at Quetta (AZRI) and Tomagh in June 1990. At AZRI, the saltbush seedlings were planted on a site where few other perennial plants grow, whereas at Tomagh, the seedlings were planted among the native bunch grasses, *Cymbopogon schoenanthus* and *Chrysopogon aucheri*. The three treatments were:

- fertilizer: manure, N plus P, and no fertilizer (three levels)
- plant spacings: 2.5 and 2.0 m (two levels)
- water-catchment system: saucer-shaped, V-shaped (two levels)

These treatments combine to give 12 treatment combinations in a factorial design with two replicates. The fertilizer was applied to each plant as a single dose equivalent to 11.5 kg nitrogen and 11.5 kg phosphorus/ha, as Nitrophos (23.23.0, 50 kg/ha). Manure was applied to each plant at a rate equivalent to 1 t/ha. A single irrigation of 15 l/plant was applied at planting. The saucers have a diameter of nearly 2 m and the Vs have arms of 2 m length at 90° to each other. Measurements of plant survival, height and crown diameter are being made every month on the same five individually tagged plants in each plot. The experiment will end in June 1993, when the biomass of leaves and wood of plants will be determined using destructive methods.

Markedly contrasting growth patterns of saltbush were seen at AZRI and Tomagh, which have different levels and distributions of rainfall, as well as soils (Figure 2.1). The total rainfall during the period from July 1990 to June 1991 and from July 1991 to June 1992 was 391 and 332 mm at Quetta AZRI, respectively, and 424 and 341 mm (excludes October to December 1991), respectively at Tomagh. The distribution, however, at the two sites differs: at Quetta, rainfall is concentrated during winter and spring, whereas at Tomagh, rainfall during the summer monsoons makes a large contribution to the annual total (Figure 2.1). The mean minimum temperatures at Quetta and Tomagh are also different, even though the altitude at Quetta (1680 m) is slightly lower than at Tomagh (1800 m).

At Quetta, the plants are growing on soil that was transported in and placed over the underlying gravel beds that form the base of the AZRI research station. The soil is thought to be fairly fertile, although no analyses have been made. In contrast, the soils at Tomagh are very shallow, with a calcareous hardpan 15-20 cm below the surface. This would affect root development, as can be seen in the next experiment on different water-harvesting methods.

The clear effect of climate on the pattern of growth of saltbush is reflected in the increasing crown diameter of plants growing at AZRI and at Tomagh (Figure 2.1). Following planting in June 1990, seedlings at AZRI showed little growth during the autumn, when moisture but not temperature was limiting, and during winter, when temperature but not moisture was limiting growth. Growth started again in March 1991, when temperatures began to rise and was rapid until June, when lack of moisture probably started to limit growth again. A period of dormancy followed until April 1992, when growth started again. Even though growth expressed as crown diameter was less in the second summer 1992 than in 1991, it continued until October 1992, as compared with July in 1991. This may have been because more moisture was stored, following excellent rain (132 mm) in April 1992 at AZRI.

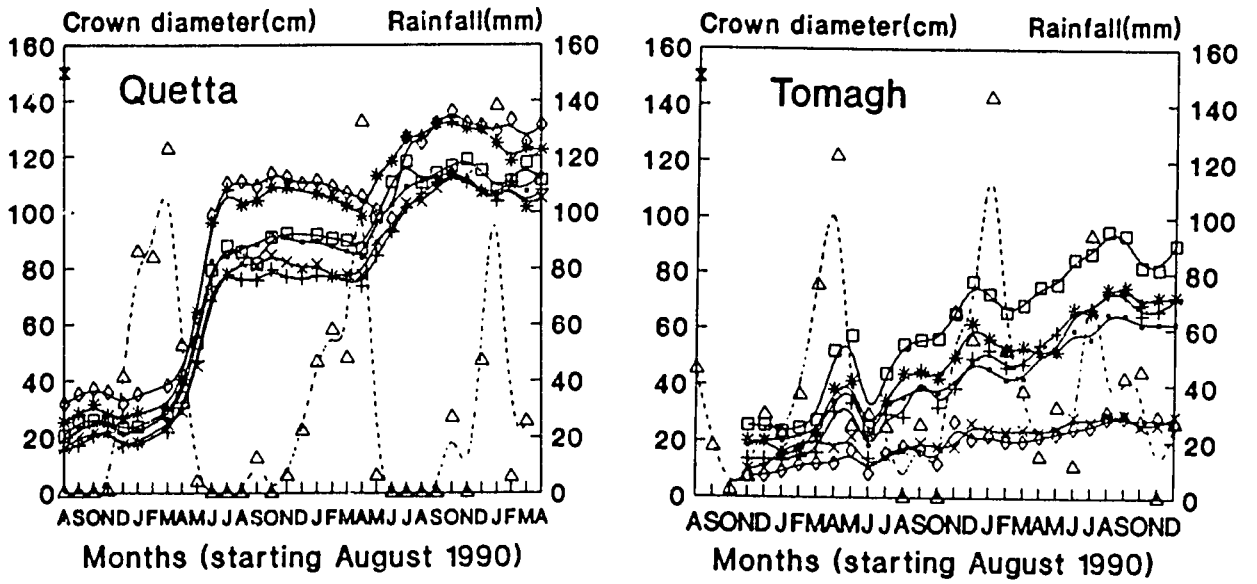


Figure 2.1. Effect of two methods of micro-basin water-harvesting, manure and fertilizer on crown diameter of saltbush at Tomagh and at AZRI station (—— = manure, V-shape, —+— = N+P, V-shape, —✱— = manure, saucer shape, —⊟— = N+P, saucer shape, —✕— = zero N+P, V-shape, —◇— = zero N+P, saucer shape, ··△·· = total monthly rainfall). (Only shows 2 m plant spacing.)

At Tomagh, a different growth pattern was seen and the plants were, in general, smaller than at AZRI (Figure 2.1). Crown diameter remained fairly constant from November 1990 until February 1991 and then increased rapidly owing to rising temperatures and good rainfall. Marked contrasts in growth, however, were seen between treatments, which are discussed below. The decrease in crown diameter in June 1991 may have been a measurement error that affected all treatments. From July 1991 until the end of the experiment in December 1992, growth continued at a steady rate, even during winter. This suggests that winter temperatures were not low enough to stop growth and sufficient moisture was generally available. Indeed, the good rainfall during the winter 1991/92 accelerated growth of the plants from October to December 1991, especially of those receiving fertilizer and manure. After a short period of relative dormancy in January and February 1992, growth continued throughout the summer of 1992 and only slowed during the period September to December 1992, when lack of moisture may have been the limiting factor.

Only the main effects of fertilizer application on crown diameter were statistically significant at Tomagh, and these effects persisted, even when adjusted, using crown diameter in November 1990 as a co-variate. This effect can be seem in Figure 2.1. The benefits of added plant nutrients at Tomagh, but not at AZRI, suggest that the soils at Tomagh are low in fertility, compared to the soils at AZRI. This suggestion needs to be confirmed, using the chemical composition of the soils.

At AZRI, treatment effects on crown diameter were similar during the autumn and winter dormant period, but effects began to emerge during the period of rapid growth in the spring of 1991. The increased crown diameter from harvesting water

in saucer-shaped basins as compared with V-shaped catchments was generally highly significant ($P<0.001$), with the statistical significance of the main effects of plant spacing and fertilizer on crown diameter being somewhat lower over the period August 1990 to December 1992. During the 10 months after June 1991, the plants growing in saucers with no fertilizer or with manure tended to have larger crown diameters than the plants in the other treatments. This difference persisted through to December 1992. When the initial differences, however, in crown diameter were removed, using the crown diameter in August 1990 as a covariate, the significance of the main effects was seldom statistically significant ($P>0.05$). There were no significant interactions between plant spacing, fertilizer application and water-harvesting design.

The conclusion drawn from this preliminary analysis of the data is that, at AZRI, growth of saltbush plants is similar under the two water-harvesting designs and that adding inorganic fertilizer or manure had little beneficial effect. In contrast, inorganic fertilizer and manure enhanced plant growth on the infertile and shallow soils at Tomagh. At both sites the height of the plants and crown diameter responded similarly to the various treatments.

Abid Hussain: principal investigator

Comparisons of different methods of water-harvesting (Protocol R03)

Ways have to be found to ensure that saltbush establishes quickly after planting, without the need for additional watering. This reduces the amount of work to be performed by farmers and should make then more willing to adopt the technology. Planting has to be completed before the long, dry period in summer, and even during the planting season from December to late February rainfall can be insufficient for plant growth and survival. It is therefore important to harvest as much water as possible close to the plant.

The four ways of harvesting water being investigated in the trial are:

- saucer catchments; each saucer has a 2 m diameter,
- V-shaped catchments: the Vs have 2 m arms at 90° to each other,
- contour furrows: at 2 m spacing, and
- ripping: at 2 m spacing.

Six month-old seedlings were planted in June 1990 at Zarchi and Tomagh[1] into native range dominated by *C. schoenanthus* and *C. aucheri*. A single irrigation of 15 l/plant was given. The trial is laid-out as a randomized complete block design with four replicates. Survival rate, crown diameter and plant height are measured every month on the same tagged plants. Only the results from Tomagh are reported here since growth of saltbushes at Zarchi in all trials has been poor, except under irrigation. This suggests that Zarchi, with a mean annual rainfall of about 200 mm, is too dry compared with Quetta which receives annually about 220 mm rainfall. Also the soils where the trials are laid out are quite shallow and stony and thus have little water-storage capacity. These arguments are supported by the good growth of bushes at a site below Zarchi station, where the soils are better, some water can runon to the site (known as the *sailaba* system) and there is no competition from sagebrush (*Artemisia maritima*).

---

[1]The trial at Mastung was abandoned since poor seedlings with a single shoot were used and many of them were damaged by a heavy infestation of rodents.

During the first four months after transplanting there was some growth of the saltbushes, expressed as crown diameter (Figure 2.2). During this period soil moisture was available and minimum temperatures were above 10°C. Thereafter the crown diameter of plants decreased until January, probably due to leaf-drop and damage by rabbits which are common in the area. Beginning in January 1991, no increase in crown diameter was then seen until March. This is difficult to explain since even though low temperatures may have limited growth until April, this would not have been the case thereafter when moisture was adequate. By July 1991 a period of steady growth occurred that continued for 18 months until December 1992. This is the same finding as in the other experiment at Tomagh reported above. It suggests that once the bushes are established, they can continue to grow through winter at a rate similar to the summer period.

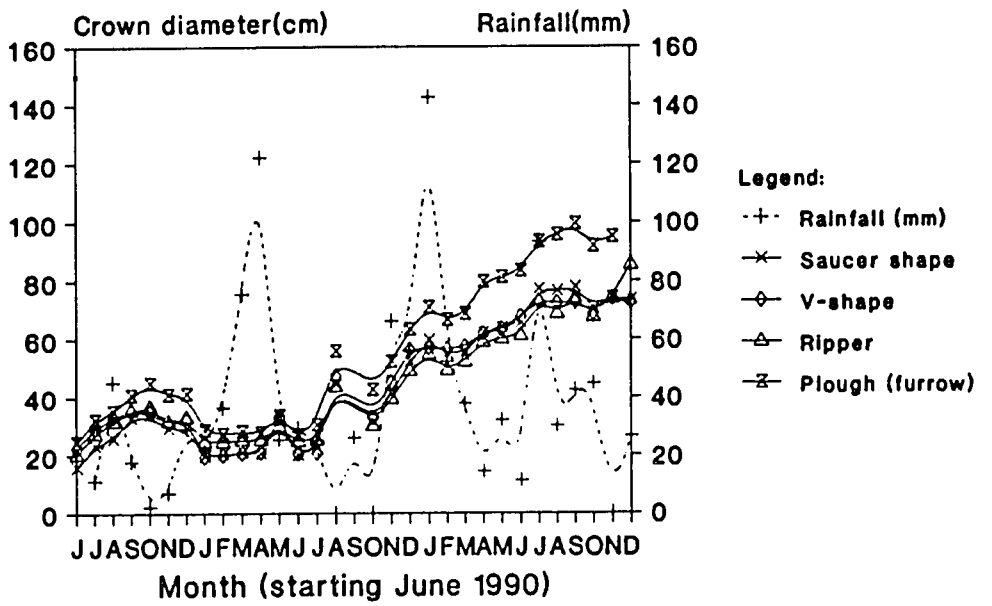


Figure 2.2. Effects of two methods of water-harvesting (saucers, V-shaped catchments) and two methods of land preparation (ripping, ploughing) on crown diameter of saltbush at Tomagh. Total monthly rainfall also shown.

There were no statistically significant (P>0.05) effects of the different water-harvesting designs on crown diameter, although the bushes planted in furrows tended to be larger. This may be related to the better catchment of water in the furrows rather than breakage of the hardpan, since it is likely that the ripper would have broken the hardpan too but the bushes were smaller.

It is difficult to conclude from this study at Tomagh that one water-harvesting or land preparation treatment is better than the other since it is not known what role the hardpan plays in determining plant and root growth. Furthermore, the magnitude of the effect of competition from the bunch grasses is also unknown. However, from a practical standpoint ploughing would be the land preparation method of choice since it can be mechanized and appears to result in the largest plants among the treatments compared. Indeed, saucers and V-shaped catchment designs would appear to be impractical due to their high labour costs. These costs have to be very low to give range improvement technologies a chance of being accepted by government agencies, let alone farmers.

Abid Hussain: principal investigator

Effects of plant spacing on growth (Protocol R04)

Experience with forage reserves of saltbush at AZRI has shown that, if stands become too dense, they are poorly utilized by sheep and goats. The purpose of this study was to find the optimum plant density that maximizes carrying capacity. It is anticipated that the closer plant spacing will make better use of the scarce rainfall, because more will be used by the plants rather than being lost as evaporation. The life-span, however, of closely spaced plants may be shorter because of competition effects. This will be less serious, provided the plants remain small as a result of grazing.

The study is being conducted at two locations; AZRI station, Quetta, and Karkhasa National Park near Quetta (Forestry Department, Government of Balochistan). At each location, two blocks (replicates) each of 3000 m^2 and differing in their soil types, were planted with six-month old seedlings in February and March 1991. The three plant spacing treatments being applied within each block are: 1 x 1 m (10,000 plants/ha), 2 x 2 m (2,500 plants/ha) and 3 x 3 m spacing (1,111 plants/ha). Every two months, data are collected on survival rate (mortality), plant height and crown diameter. Plant biomass was estimated from the regression between plant biomass, which ranged from 0.0018 to 2.9942 kg, and plant height and crown diameter, which ranged from 15 to 110 cm and 10.5 to 135 cm, respectively, ($P<0.001$, $n = 27$, $r^2=0.90$).

Apart from ground cover, there were no statistically significant effects of plant spacing on the various parameters measured and estimated plant biomass. The expected trends, however, are sufficiently interesting to deserve comment (Table 2.1). Individual plant volume doubled, but plant volume per hectare decreased by about 75 percent, as plant density decreased from 10,000 to 1,111 plants per hectare. This resulted in a four-fold difference in individual plant biomass, much better ground cover and a higher rainfall-use-efficiency in closely spaced plants. Survival rate was similar across the spacing treatments.

Table 2.1. Plant dimensions, volume, biomass, ground cover, rainfall-use-efficiency and survival at the November 1992 sampling, at three plant spacings (S) and two locations (L), AZRI and Karkhasa

	Plant spacing (m)			SED	Sign.[1]	
	1x1	2x2	3x3		S	L
Plant height (cm)	58	62	67	10.3	ns	ns
Crown diameter (cm)	58	63	78	16.9	ns	ns
Plant volume (m^3)	0.11	0.16	0.24	0.104	ns	ns
Plant volume (m^3/ha)	1065	409	268	268.3	ns	ns
Biomass (kg DM/ha/2 yrs)[2]	2922	1123	735	-	-	-
Ground cover (m^2/plant)	0.27	0.35	0.51	0.189	ns	ns
Ground cover (percent)	26.7	8.7	5.7	10.7	*	ns
Rainfall-use-efficiency[3]	4.18	1.61	1.05	-	-	-
Survival (percent)	95.1	95.0	90.6	2.79	ns	ns

[1]Levels of significance: ns = $P>0.05$, * = $P<0.05$.
[2]Estimated from regression between biomass and plant volume.
[3]kg dry matter (DM)/mm rainfall/ha. Based on rainfall (698.6 mm) between October 1990 and October 1992.

In regions where rainfall is so low that efficient use of moisture is a priority, these preliminary results indicate that rainfall-use-efficiency can be markedly improved by using close plant spacing. During the coming season, however, the effects of inter-plant competition should become apparent, especially in the closely spaced plants which could make high plant density less attractive. Indeed, it is generally considered that a plant population of 1000 per hectare is closer to the level that allows persistency of the population. It is also unlikely that farmers will consider planting well over 1000 plants per hectare because of the high costs involved. It is planned to graze half of each plot in 1993, so that the further development of both ungrazed and grazed plants can be studied.

Javed Afzal: principal investigator

Grazing potential of saltbush (Protocol R08)

It is essential that grazing studies be conducted to investigate the carrying capacity of saltbush and its persistency. It can withstand moderate to heavy grazing pressure (Rumbaugh *et al.*, 1982), but, without, suitable grazing management sustained production is not maintained (Jefferies and Pitman, 1986). Utilization of saltbush by animals is generally recommended after 18 to 24 months of growth (Ueckert, 1985). The adoption potential, however, of saltbush is likely to be reduced if farmers have to wait this long. Therefore, some of the saltbush planted on farm land in March/April 1992 was grazed in December 1992.

A new grazing study on saltbush at AZRI, which also serves as a training exercise, is investigating the persistency, offtake and carrying capacity of saltbush under different grazing regimes. Since the study started late in the growing season, only a simple comparison was made of the potential of saltbush grazed in a continuous (set-stocked) or a deferred regime. The latter involved twice the grazing pressure of the continuous regime but for half the duration. Moreover, grazing in one of the deferred plots ended eight weeks before grazing in the other deferred plot and in the continuously grazed plot. This could affect the level of root reserves in plants entering the winter period and ultimately the persistency of the plants. The trial used Balochi and Harnai yearling rams. They were offered a basic diet of wheat straw, since it was anticipated that the saltbush alone could not maintain the liveweight of animals during the autumn period, when plant growth diminishes owing to a lack of soil moisture.

Two adjacent blocks (replicates) of saltbush, one of 35 x 152 m and the other of 41 x 143 m, established in the early summer of 1987[1] at AZRI were used. Each block was divided into three plots, and starting in July, one plot in each block was grazed continuously by five sheep for 16 weeks at a stocking rate of 28.3 sheep/ha. Grazing by 10 sheep in one of the other two plots in each block started on the same day and continued for eight weeks. The sheep were then moved to the other plot for another eight weeks. Thus the mean stocking rate in these two plots was also 28.3 sheep/ha, but one was grazed later into the autumn than the other.

At the start of the study all leaves from seven plants in each plot were removed, weighed, and dried to determine biomass available at the start of the study.

---

[1]This is not altogether clear since some of the plants were grown directly from seed sown in the plots in 1984 or 1985.

Eight plants in the continuously grazed plots were protected by 1.5 x 1.5 m cages and the biomass of leaves on them measured at the end of the study. The leaf biomass of other plants exposed to grazing in each plot was determined at the end of grazing. This made it possible to estimate the amount of leaf available at the start and end of grazing, and the amount apparently removed by the sheep. Plant height and crown diameter were also measured on 50% of the plants in each plot, before the start of grazing.

Sheep grazed from 8.00 to 12.00 h and then returned to pens for water and chopped wheat straw, which was offered at a daily rate of 500 g/sheep. Samples of straw were taken for dry matter analysis. Sheep were weighed at the start of the trial, then once a week until the trial ended. The trial will continue in the spring of 1993 after plants have been pruned. The weight of the prunings will be measured.

The preliminary results from the trial are shown in Table 2.2. There are unlikely to be statistically significant differences between the two grazing regimes, with sheep in both treatments gaining 13 to 18 g daily. About 1100 kg dry matter (DM)/ha leaves were on offer at the start of the trial, and intakes of leaves and wheat straw were the same in the two treatments. The total intakes were about 20 g DM/kg liveweight or 47 g DM/kg metabolic body weight. This intake of saltbush leaves is higher than that by the pen-fed sheep offered little wheat straw in the trial reported below.

These results indicate that, in the autumn, sheep grazing saltbush need to be supplemented with wheat straw to allow modest liveweight gains. The saltbush could have provided a higher proportion of the diet at a lower stocking rate but the duration of grazing would have been shorter. Currently it is not known how farmers will manage their saltbush reserves and, therefore, it is important to expand the area and number of reserves on farms, so that these can be grazed by farmers' animals. Meanwhile, grazing studies are needed which will give researchers the information necessary to advise farmers on grazing regimes that allow good offtake from saltbush reserves, without jeopardizing the persistency of the plants.

Table 2.2. Grazing days, liveweights and average daily gains of sheep, grazing offtake of saltbush leaves, and intake of saltbush leaves and wheat straw in a continuous and deferred grazing regime

	Continuous	Deferred[1]
Initial liveweight (kg)	29.8	27.8
Final liveweight (kg)	31.8	29.3
Average daily gain (g)	18	13
Offtake of saltbush (kg/head)		
Initial Biomass	20.0	20.0
Final Biomass	2.8	3.0
Offtake	17.2	17.0
Intakes (g DM/day)		
- saltbush leaves	154	152
- straw	466	429
- total	620	581

[1]Sum of two eight week grazing periods.

Sarwat N. Mirza: principal investigator

Establishment of Artificial Plant Communities (Protocol R09)

Due to a severe shortage of staff in the Range Section, little progress has been made towards initiating this project. However, an artificial block of *Chrysopogon aucheri*, the indigenous palatable bunch grass, was established at Tomagh in the spring of 1992. Efforts will continue in 1993 to expand the *in situ* herbarium at AZRI. It already has a number of species of saltbushes growing in it such as *A. canescens*, *A. halimus*, *A. nummerlaria*, *A. lentiformis*, *Salsola vermiculata*, and some native tree and shrub species such as *Prunus eburnea*, *Pistacia khinjuk*, *Convolvulus leiocalycinus*, *Olea ferruginea*, *Berberis sp.*, *Fraxinus xanthozyloides*, and *Prunus sp.* (wild cherry).

Seedling multiplication (Protocol R10)

Intact seeds of fourwing saltbush do not germinate under field conditions and can only be raised as seedlings in nurseries. This seems to be related to the thick protective seed coat as well as to certain chemical inhibitors. To cater for the large increase in the demand for seedlings in 1993, AZRI has started to expand its nursery and by the spring of 1993 it should have a capacity for up to 200,000. It is also hoped that the Forest Department and selected villages will establish their own nurseries.

A plastic tunnel with a capacity of about 10,000 seedlings will also be constructed so that some seedlings can be grown throughout the winter. The construction costs will be paid from the Rs1.6 million awarded to AZRI as part of the Productivity Enhancement Program (PEP) of PARC. The award is part of a project on the use of salt affected areas.

Effects of watering frequency on establishment rate (Protocol R12)

When soil moisture levels are low, it is essential to use a small irrigation to ensure the successful establishment of saltbush. This is the case when planting is after early May when little further rain is expected and is particularly true if the rainfall in spring has been poor. In several of the present experiments about 15 liters of water (a bucket-full) were applied at planting.

An experiment was conducted at Zarchi which aimed to investigate the effect of watering frequency on the performance of saltbush. The seedlings were planted in pits at Zarchi in May 1990 at a spacing of 1.5 x 1.5 m in a randomized complete block design layout with four replicates and three treatments. At each watering one bucket full of water (about 15 liters) was given to each plant. The same four plants in each treatment and replicate were sampled for crown diameter and plant height once every month until December 1992. The treatments were: 1) watering once every week, 2) watering once every two weeks, and 3) watering once a month.

The plants watered once every two weeks tended to be taller than the plants in the other two treatments and this improvement was generally statistically significant ($P<0.05$). However, the growth of the plants was poor, as in most experiments at Zarchi, despite the additional watering. This finding suggests that other factors are limiting growth, such as a lack of top soil where the experiment is being conducted. Interpretation of the results is not attempted and the experiment has been terminated.

Abid Hussain: principal investigator

Construction of a dewinger for seeds

Removing the wings of saltbush enhances germination rate and previously was a labourious manual task involving rubbing the seed between a brick and a piece of canvas. To accelerate this process, an electrically powered dewinger was constructed by staff of the Farm Machinery Institute (FMI) at NARC, Islamabad. It is rather like a food processor/blender, except that it has four rigid and blunt steel bars at rightangles to each other that form a cross. They rotate at high speed within a steel container. The machine is now being used at the AZRI nursery.

Establishment of saltbush forage reserves on farmers' fields (Protocol Ex01)

The on-farm testing of a technology with the full involvement of farmers puts the technology to its greatest test, since, if it is not adopted by farmers, then the preceding research is of little value. This is especially the case in developing countries where the research resources of national programs are desperately short. For this reason, AZRI started establishing saltbush forage reserves in 1988 at Zarchi and Kovak. In 1990, it planted saltbush in the buffer zones of its water-harvesting trials, and, in 1991, started inter-cropping studies at two sites in Spezand. No fencing is used at the sites established in 1991 and 1992 since the technology must succeed without it, and no rent is paid for the use of the land.

A new site, at Miangundi, was added in 1992. It is close to the main migration route of nomads and a guard, therefore, is employed to protect the saltbushes from grazing. In late March/early April 1992, about 2000 seedlings were planted on sloping deep soil largely free of range vegetation. Ridges with 4 m spacing were prepared along the contour with a disc-plough and seedlings planted on the uphill side of the ridge at 1 m intervals. A further 8000 seedlings were planted at the same intervals directly into 25 x 40 cm pits on adjacent sloping rangeland which supports a good stand of *Artemisia maritima*. Only the survival rate of the plants is being monitored.

Approximately 100 mm rainfall fell in April, resulting in good plant establishment. Growth was better than expected and by December, sheep and goats from local herds were allowed to graze the shrubs until most of the leaf had been removed. No recordings were taken of grazing days. The decision to graze was taken, since it is considered that farmers are more likely to establish their own saltbush reserves if it can be grazed during the first winter. The saltbush must, however, be able to tolerate this grazing pressure, which is a subject for detailed grazing studies. Further forage reserves will be established on farm land in 1993.

Bilal Chaudhry (Extension Section), Mohammad Islam (Agronomy Section): principal investigators

Nutritive value of saltbush

Saltbush is being studied for its potential both as a supplement to grazing on rangelands which are generally heavily degraded owing to over population of small ruminants and removal of the shrubs, for fuelwood and as a supplement to other feeds such as wheat straw. A study was conducted at AZRI to investigate the

value of saltbush as a supplement to a basic diet of wheat straw purchased from the local market. Effects of feeding saltbush on levels of sodium, calcium, phosphorus and potassium in the blood were studied and daily water intake was recorded.

The study had three phases. In a standardization phase of six days, sheep were offered *ad-libitum* chopped wheat straw and 200 g daily of un-decorticated cottonseed cake (CSC), containing about 20 percent crude protein in the dry matter (DM). During the main experimental phase which lasted for 28 days, four groups, each containing four mature Harnai male castrates, were offered *ad-libitum* wheat straw in addition to one of four levels of sun-dried saltbush (*A. canescens)* leaves hand-harvested in November and December 1991. The four levels were 150, 300, 450 and 600 g of leaves (air dry matter). Faeces were collected during the last 7 days of the experimental period. Feed, refusal and faecal samples were dried and ashed according to standard procedures and intakes of dry matter (DMI) and organic matter (OMI), and digestibility of the dry matter (DMD) and organic matter (OMD), and D value, were calculated. (D value is the amount of organic matter digested per 100 g dry matter ingested.)

The final phase of the experiment lasted 13 days, when sheep were again offered *ad-libitum* wheat straw and 200 g CSC. Faeces from one sheep in each group were collected, so that the digestibility of the wheat straw/CSC diet could be calculated.

There was a tendency for the DMD and OMD to remain the same at the low and medium levels of feeding saltbush leaves and then to decrease at the higher levels. The treatment differences, however, were only significant in the case of the OMD (Table 2.3).

Table 2.3. Digestibility of dry and organic matter, D value, daily intakes of dry and organic matter, and daily gains of sheep offered diets containing four different proportions of saltbush leaves and wheat straw

	Proportion FWSB in total DMI				SD[1]	Sign.
	Low (0.15)[2]	Medium (0.29)	High (0.49)	V. high (0.69)		
Number of observations (n)	4	3[3]	4	3[3]	-	-
Digestibilities (%)						
- dry matter	52.4	53.3	48.9	44.4	4.41	ns
- organic matter	54.7	54.3	50.1	43.3	4.68	*
- D value	48.2	47.0	42.2	35.7	3.90	**
Total intakes (g/day)						
- dry matter	892	939	836	765	61.2	*
- organic matter	785	814	707	631	54.3	**
- dry matter ($/W^{0.75}$)	66.8	74.0	63.3	58.2	8.4	ns
- organic matter ($/W^{0.75}$)	58.8	64.0	53.5	48.1	7.2	ns
Daily gains (g)	41	10	-14	-100	39.8	*

[1]Residual standard deviation can be used to calculate standard errors for comparisons of treatments where the n contributing to each mean differs.
[2]Actual proportion of saltbush leaves in the diet.
[3]One sheep in each of these treatments refused large amounts of saltbush leaves and for this reason the data were not included in the analysis.

There were statistically significant differences between the treatments in terms of DMI and OMI (Table 2.3). Definite trends were apparent. The total intakes at the low and medium levels of inclusion of saltbush leaves were similar, but decreased as the proportion of saltbush leaves in the total diet increased.

Linear regression analysis was conducted between the proportion of saltbush leaves in the total diet (S) and DMD, OMD, DMI and OMI (Table 2.4). This made it possible to estimate the digestibilities and intakes for diets containing wheat straw only and saltbush leaves only. The DMD and OMD of the wheat straw were high, and conversely, the DMD and OMD of the saltbush leaves low. The digestibility of straw from the local landrace of wheat has not yet been determined at AZRI and there is no information about the origin of the straw. One would expect *in vivo* DMD values up to 50 percent. Indeed, the best wheat straw determined by ICARDA in Syria reached 44 percent (PFLP, 1987). The DMD and OMD values of the wheat straw used in this experiment are therefore surprisingly high[1]. Similarly, the DMD and OMD values of the saltbush leaves are surprisingly low.

The decreasing OMI and digestibility in the total diets as the proportion of saltbush leaves increased is reflected in the decreasing liveweight gains of the sheep (Table 2.4). The sheep would have been neither gaining nor losing liveweight at a saltbush proportion in the total diet of 0.38.

Table 2.4. Constants of linear regressions between dry matter (DMD) and organic matter (OMD) digestibility of the total diet, and daily total dry matter (DMI) and organic matter (OMI) intakes, and the proportion (S) of saltbush leaves in the total diet.

Y	a[1] (SE)	b (SE)	R	P	RSD	S[2]
DDM	55.6 (2.55)	-14.4 (5.73)	0.58	0.0274	4.37	41.2
DOM	58.5 (2.77)	-19.3 (6.21)	0.67	0.0091	4.74	39.2
DMI	977.7(32.69)	-299.9(73.38)	0.76	0.0015	56.0	677.8
OMI	869.9(27.31)	-338.8(61.29)	0.85	0.0001	46.8	531.1

[1]These values indicate the estimated values for diets containing no saltbush leaves.
[2]When S=1, the diet contains 100 percent saltbush leaves.

It was only possible to get the sheep to eat close to the highest level of saltbush leaves by limiting the amount of wheat straw on offer. This finding is in marked contrast to an earlier experiment in which sheep consumed, without difficulty, 700 g daily (air-dry basis) of saltbush leaves, even when offered 400 g daily of barley grain or cottonseed cake as well (Atiq-ur-Rehman, unpublished data). One possible explanation for these contrasting results is that, in the present study, the leaves were harvested late in the season, when their digestibility was low, whereas in the study of Atiq they were harvested in June.

[1]In recent studies at ICARDA in Syria, the supplementation of a basal diet of barley straw (45 percent DMD) with leaves of saltbush (A. halimus), increased straw intake at both the 200 and 400 g (air-dry matter) level of leaves offered (Goodchild et al., 1993). The calculated DMD of the saltbush was about 70 percent and it contained about 150 g crude protein/kg DM. These authors suggest that the increased intake of straw was because the saltbush leaves removed the protein deficiency in the straw which contained 33 g crude protein/kg DM.

Further studies are needed before it can be stated that saltbush harvested at the beginning of winter has a feeding value below the maintenance requirement of local sheep. It appears, however, that sheep browsing on saltbush late in the season would also need to be fed wheat straw, if the range grazing were poor as is usually the case.

E. Rasool: principal investigator

Future research

The experiments described by Protocols R02 and R03 will be terminated in 1993 after taking final measurements. The plant spacing trial (Protocol R04) and grazing trial (Protocol R08) will be continued. The main activity will be the expansion of the areas planted on marginal land owned by farmers and the establishment of saltbush plantations on salt-affect land. Both these activities will be supported by the funds which are available under the Productivity Enhancement Program (PEP) of PARC.

References

AZRI/ICARDA (Arid Zone Research Institute/International Center for Agricultural Research in the Dry Areas) 1991. 1990 Annual Report. MART/AZR Project Research Report No. 65, ICARDA, Quetta.

Goodchild, A., Treacher, T.T., Rihawi, S. and Termanini, A. 1993. Review of recent work at ICARDA on the quality of feeds and supplementation strategies. Pasture, Forage and Livestock Program. ICARDA, Aleppo, Syria. Unpublished manuscript. pp. 11.

Jefferies, R.L. and Pitman, M.G. 1986. Perspectives of the biology of halophytes in natural habitats in relation to forage production. In: Forage and fuel production from salt affected wasteland. Editors: Barrett-Lennard, E.G., C.V. Malcolm, W.R. Stern and S.M. Wilkins. Elsevier, Amsterdam. Pages 227-244.

PFLP (Pasture, Forage and Livestock Program) 1987. Pasture, Forage and Livestock Program, Annual Report 1986. ICARDA, Aleppo, Syria. pp. 178-185.

Rumbaugh, M.D., Johnson, D.A., Van Epps, G.A. 1982. Forage yield and quality in a great basin shrub and legume experiment. Journal of Range Management 35: 604-609.

Ueckert, D.N. 1985. Use of shrubs for Rangeland Revegetation. In: Proceedings of the International Ranchers Roundup. Laredo, Texas. Editors: L.D. White, D.E. Guyn, and T.R. Troxel. Texas Agricultural Extension Service. Pages 190-196.

Chapter 3

SMALL RUMINANT RESEARCH[1,2]

Introduction

Two years of studies are now complete which focused on the effects of body condition score on the fertility of Balochi and Harnai ewes and the benefits of winter supplementation during late pregnancy and early lactation. During the previous studies in 1988/89 and 1989/90, ewes were grouped at random and balanced for age and body weight and all the ewes were fed prior to mating and lambing without consideration of their body weight group. The purpose of supplementation was to study whether there was an impact of feeding on fertility and lamb performance. Very encouraging results were obtained in these two studies.

During the 1990/91 season assessment of the general condition of animals was introduced using the body condition scoring (BCS) method describe elsewhere (AZRI/ICARDA, 1992). The method shows how a ewe with a large frame might weigh over 40 kg but be in poor condition and thus need feeding to ensure that she conceives and lambs. On the other hand, a ewe with a smaller frame size might weigh just 20 kg but be in good body condition and not need feeding. Therefore, indiscriminate feeding of all ewes, whether thin or fat, light or heavy, is expensive when only thin ewes need to be fed to ensure conception and completion of pregnancy. Ewes were therefore grouped according to BCS, and using more focused supplementation, improvements in the fertility are expected at lower cost.

The research of the Livestock Section at AZRI focuses on:

- raising sheep and goats under grazing conditions with minimal supplemental feeding and monitoring their performance under different ecological conditions in Balochistan,
- determining the time in the annual reproductive cycle when feeding supplements gives the maximum biological return,
- estimating the cost-benefit ratio of raising range-based sheep and goats with minimal use of supplemental feeds,
- using *in vivo* methods to assess the nutritive value of different feeds produced in arid and semi-arid areas,
- measuring the impact of different diseases on the productivity of range sheep and goats, and
- determining the performance of sheep and goats in farm flocks.

Shahid Rafique: Head, Livestock Section

Winter Supplementation/Nutritional Management Studies[3]

A study into the fertility of Harnai and Balochi ewes as influenced by differences in BCS and supplementation during mating, was conducted at both Tomagh and Zarchi Range-Livestock Research Stations in 1991/92.

---

[1]This sections was written by the staff of the Livestock Section and edited by E.F. Thomson (ICARDA advisor).

[2]Much of the research reported in this chapter is now supported by a BOSTID grant.

[3]A study on the feeding value of saltbush supplemented with wheat straw is reported on page 16.

Tomagh study: Seventy-five, one-to-five year old Harnai ewes were divided at random to give a low (1.0-1.5) and a medium (2.0-2.5) BCS group balanced for age. The 22 ewes with a medium BCS grazed the *Chrysopogon/Cymbopogon* dominated range and received no supplement. The other 53 ewes with a low BCS were sub-divided at random to give two sub-groups of 27 and 26 ewes. The first sub-group served as a control and was managed in the same way as the medium BCS ewes. The 26 ewes in the other sub-group were each fed a daily ration composed of 500 g whole barley grain and 100 g cottonseed cake, in addition to grazing. Feeding started on November 1, 1991.

Starting on November 21, two Harnai rams were given 24 h access to ewes and a third ram was introduced on December 19, 1991. This resulted in random mating by multiple sires. Rams were removed on January 16, 1992 and feeding ended one month later. However, maintenance feeding to all ewes then started, based on 200 g barley grain, 100 g cottonseed cake and 500 g wheat straw daily, for each ewe.

Ewes grazed together the native range for eight hours each day and the supplemented ewes were fed in the afternoon when they returned from grazing. Survival rations were fed to very weak and thin ewes. Water was freely available when ewes were housed in the afternoon and at night. They were all vaccinated against prevalent viral and bacterial diseases and drenched for internal and dusted for external parasites. Ewes were weighed every 15 days.

Zarchi study: Seventy-three, one-to-five year-old Balochi ewes were divided at random to give a low (1.0-1.5) and a medium (2.0-2.5) BCS group. The fifty-two ewes in the low BCS group were sub-divided again. The ewes in one sub-group served as a control and received only grazing whereas the ewes in the other sub-group were given a daily supplement composed of 500 g whole barley grain and 100 g cottonseed cake, in addition to grazing. The twenty-one ewes in the medium BCS group and the 52 ewes in the low BCS group grazed as one flock a sagebrush (*A. maritima*) dominant range for eight hours each day. The botanical and chemical composition of the Zarchi range vegetation during the different seasons of the year is given by Jasra (1990). Feeding started on November 1, 1991 and supplements were offered in the afternoon when the ewes returned from grazing. Small amounts of supplement were provided as survival rations to very weak and thin ewes in the control group. Ewes were watered in the morning and afternoon. All the ewes were vaccinated against the prevalent viral and bacterial diseases and drenched for internal and dusted for external parasites. Ewes were weighed every 15 days.

Three Balochi rams were introduced into the experimental flock on December 17, 1991, to give random mating with multiple sires. They were removed on January 28, 1992 and feeding of low BCS ewes ended on February 29, 1992. All ewes were then fed for one month a maintenance ration comprising 200 g whole barley grain, 100 g cottonseed cake and 500 g chopped wheat straw.

The same feeding regime as used during the breeding period was resumed on April 1, 1992 but because ewes were refusing supplements since the range was good following abundant rains, feeding was stopped again on April 15. Lambing started on May 16, 1992 and lambs were weaned when they were 1.5 to 2 months old.

Results and Discussion. The results from the trials at Tomagh and Zarchi are shown in Tables 3.1 and 3.2. At Tomagh the lambing rate was the same in the low BCS ewes, whether or not they received supplements. In the medium BCS ewes that received no supplement, lambing rate was 82 percent.

Table 3.1. Fertility and mortality during pregnancy of Harnai ewes at Tomagh, 1991/92

Body condition score	Low		Medium
Supplement	None	Plus	None
Total number of ewes	27	26	22
No. of ewe deaths	1	3	1
No. of ewes lambing	20	19	18
No. of twins	0	0	0
No. of lambs born	20	19	18
Lambing rate (percent)	74	73	82
Prolificacy (percent)	1.0	1.0	1.0
Lamb birth weights (kg)	2.7	2.8	2.5

At Zarchi feeding ewes in poor body condition during the breeding period resulted in a substantial improvement in the lambing rate from 54 to 85 percent which was higher than the lambing rate in the unsupplemented medium BCS group (Table 3.2). Supplementation of low BCS ewes also resulted in an improvement in the birth weights of their lambs.

Table 3.2. Fertility and mortality during pregnancy of Balochi ewes at Zarchi, 1991/92

Body condition score	Low		Medium
Supplement	None	Plus	None
Total number of ewes	26	26	21
No. of ewe deaths	0	0	0
No. of ewes lambing	14	22	13
No. of twins	0	0	0
No. of lambs born	14	22	13
Lambing rate (percent)	54	85	62
Prolificacy (percent)	100	100	100
Lamb birth weights (kg)	1.7	2.2	1.8

The benefits to lambing rate of feeding ewes in poor body condition during the breeding season are still unclear, at least at Tomagh. For this reason the experiment will be repeated in 1993/94 as part of the BOSTID project. More ewes will be available for the experiment and a factorial design will be used, with two body condition score groups and with/without feeding treatments.

Inam Ul-Haq: principal investigator, and **Raiz Hussain**

References

AZRI/ICARDA. 1992. The MART/AZR Project Annual Report 1992. ICARDA/AZRI, Quetta, Pakistan. pp. 63.

Jasra, Abdul W. 1990. Dietary composition and nutrient status of sheep and goats grazing two rangeland types in Balochistan, Pakistan. PhD thesis, Oregon State University, Corvallis, USA.

Chapter 4

AGRICULTURAL ECONOMICS RESEARCH

Introduction

The AZRI Agricultural Economics Section continues research on livestock marketing, seasonal price indices of agricultural and animal products and the economics and risk of water-harvesting. Highlights of the livestock marketing study are presented first. These reveal how the lack of market information may bias the perceptions of those involved in livestock production and marketing. This section is followed by the text of a note that was sent to the private and public sectors to initiate a constructive discussion of what needs to be done in the livestock sub-sector to assure the sustainability of the leather industry. Hopefully this note is not the final word but rather the beginning of a follow-up of previous research on the marketing of skins.

A summary is presented of the results from the economic analysis using all the years of the water-harvesting project. This is followed by the initial results from a new study on farmers' perceptions of water-harvesting. A more complete version will be presented at the second meeting of the Dryland Resource Management Program (DRMP) planned in May 1993 in Aleppo. At this meeting the results from diverse projects of different countries in WANA will be discussed. The findings of this research, together with our knowledge of the technical aspects of water-harvesting, provide a better framework to assess the economic and social sustainability of this technology.

Abelardo Rodríguez: Agricultural Economics Advisor, ICARDA

Usman Mustafa: Head, AZRI Economics Section

Livestock Marketing (Protocol E01)

A two-year study on livestock price perceptions of producers and other market agents in Quetta market has been completed (see AZRI/ICARDA 1992, Khan *et al.* 1992). During this period the expected prices were recorded each month from 100 producers and 100 other market agents, which includes wholesalers, traders and butchers. Half of these 200 expected prices were for sheep and half for goats. A total of 4400 observations were recorded during the two-year period.

Data from the last 22 months were used to regress price per unit of live weight with the Julian days on which the data were gathered; 365 days were added to the Julian days of the second year. Results are presented in Table 4.1. Sheep and goats data are presented combined as "mutton", which includes goat meat in Pakistan, and separately. The t statistics for all regression coefficients (not shown in the table) were highly significant ($P<0.001$) with the exception of the slope of the goats in the "others" group. The intercepts, representing January 1, 1991, ranged from Rs23.6 to Rs26.3/kg and the significant slope coefficients ranged from Rs0.0054 to Rs0.0099/kg per Julian day. From January 1991 to October 1992, the estimated increase in the price of live weight of sheep was Rs6.63/kg for "others" and Rs5.29/kg for producers. This estimated price increase represents a 28 percent increase for "others" and 20 percent for producers. In both instances, the increase was above the official retail price increase of 10

percent (Agricultural and Livestock Products Marketing and Grading Department (ALPMGD), GOB Quetta). These results contrast with the survey cooperators' claim that retail prices have increased from Rs50 to Rs60/kg (over about two years), while the prices received by them in the livestock market have not increased accordingly. Informal interviews with consumers have revealed that the December 1991 price of mutton was Rs60/kg, which represents a 20 percent increase with respect to prices in January 1991.

Table 4.1. Results of regression analysis between the liveweight price (Rs/kg) of small ruminants in Quetta market and time (in Julian days). All the coefficients (intercepts and slopes) except one were highly significant (P<0.001)

	Intercept	Slope	r
All market agents			
Mutton	24.98	0.0077	0.136
Goats	24.40	0.0080	0.142
Sheep	25.56	0.0074	0.130
Producers			
Mutton	25.87	0.0097	0.149
Goats	25.13	0.1194	0.180
Sheep	26.30	0.0079	0.124
Others			
Mutton	24.58	0.0054	0.102
Goats	25.26	0.0015[ns]	0.030
Sheep	23.56	0.0099	0.180

[ns]Non-significant at P<0.10.

Prices of live animals reflect an increase in prices paid by consumers. However, the increase in prices to producers, market agents and consumers have not been concurrent. According to the ALPMGD in Quetta, it was not till January 1992 that retail prices of mutton started to increase, from Rs51/kg to Rs55/kg by October 1992. It would be desirable to have market information flowing between the producers and other market agents in such a way that price changes and trends are familiar to those involved in marketing transactions.

It was remarked elsewhere that prices perceived by different market agents should be interpreted as those prices expected at the beginning of the one-to-one bargaining process (AZRI/ICARDA, 1992). The goat liveweight prices perceived by producers were Rs29.4/kg while those perceived by the "others" were Rs25.3/kg (Table 4.2). Likewise, sheep liveweight prices perceived by producers were Rs29.1/kg and those perceived by the "others" were Rs27.1/kg. These differences reflect the nature of the market agents and their role in the marketing chain. Even though the differences appear to be small, these are the potential gains that producers could make if they knew about the supply and demand situation and if they knew what types of animals to market at particular times. The seasonal changes in liveweight prices will be analysed according to the liveweight, breed, sex, body condition and age of the animals.

Table 4.2. Liveweight, prices per head and liveweight prices of small ruminants in the Quetta livestock market (Standard deviations)

		Liveweight (kg/hd)	Price (Rs/hd)	Price (Rs/kg)	n
Goats					
Producers	Female	28.3 (9.1)	671.0 (216.6)	25.3 (9.5)	92
	Male	29.4 (12.5)	841.9 (463.2)	29.8 (11.8)	877
	All	29.3 (12.2)	825.7 (448.4)	29.4 (11.7)	969
Others	Female	30.7 (10.6)	698.5 (331.6)	23.4 (8.4)	231
	Male	28.4 (10.6)	706.6 (412.7)	25.7 (10.1)	1000
	All	28.9 (9.8)	705.1 (398.6)	25.3 (10.6)	1231
Sheep					
Producers	Female	34.4 (10.4)	828.4 (249.0)	24.8 (6.5)	73
	Male	30.5 (12.9)	848.7 (441.3)	29.4 (12.6)	1011
	All	30.7 (12.8)	847.3 (431.0)	29.1 (12.3)	1084
Others	Female	29.7 (10.8)	751.6 (315.5)	26.5 (8.4)	203
	Male	31.1 (13.0)	816.4 (406.5)	27.2 (9.6)	913
	All	30.8 (12.6)	804.6 (392.2)	27.1 (9.4)	1116

Imran Ali: principal investigator, and **Nisar Ali Shah and Mohammed Afzal**

Seasonal Price Indices (Protocol E03)

All the information has now been collected to develop seasonal price indices for agricultural and animal products in Quetta. Preliminary results were reported in the 1991 MART/AZR Annual Report and final results will be reported in a separate MART/AZR Project Research Report. The cooperation of the ALPMGD in the project is gratefully acknowledged.

Mohammed Afzal: principal investigator, and **Nisar Ali Shah and Imran Ali**

Text of a Proposal to Follow-up on the Skin-marketing Survey

After cotton, exports of leather and leather products are Pakistan's next largest source of foreign exchange (GOP, 1991a), and their value has increased from US$269 million in 1985 to US$483 million in 1990. This rapid growth has been successfully based on indigenous supplies of skins and hides. Considerable research and training have been carried out by the Leather Research Center of the Pakistan Council of Scientific and Industrial Research (PCSIR) and the Leather Products Development Organization in the processing and handling of skins and hides. However, little or no attention has been paid to the social and economic factors that affect their supply (Rodríguez *et al.*, 1992).

As long as skins are perceived as meat by-products, their supply will continue to be inelastic; that is, the supply of skins will respond to meat, rather than leather, prices. The tanning industry has the capacity to absorb more than the total domestic supply of 37.6 million skins (GOP, 1991b). Imports of raw skins have increased in recent years (GOP, 1991b) to satisfy the demand of the tanners, who have correspondingly increased their exports of leather and leather goods. Pakistan has evolved from being a net exporter of raw skins to a net importer of

raw skins and a net exporter of leather and leather products (GOP, 1991b). While this is a desirable trend in economic development, additional savings could be achieved if the domestic supply of skins satisfied the demand from the tanners (Rodríguez *et al.*, 1992).

The supply of skins is not only a function of biological aspects that determine production, but also of those marketing aspects that constrain their flow from producers to consumers. If there is market efficiency, the preferences of tanners are passed back through the marketing chain to the producers, who then respond to the price signals, producing skins as a function of prices and costs. Efficient marketing systems provide goods and services over time and space and in the form consumers want at the lowest possible cost. The inefficiencies of the skin market in Pakistan were identified three decades ago (Siddiqui, 1962), and they are still present (Mahmood and Walters, 1990; Shuja-Uddin-Siddiqi, 1992).

There are a few questions to be answered: What can be done to benefit both producers and consumers of raw skins? Can livestock producers increase their income by paying attention to factors that affect skin quality? Is there research that the Pakistan Agricultural Research Council (PARC) can do to remove constraints to a steady supply of skins to the leather industry? The next sections present the outline of a proposal to the different interested parties from the private sector and government agencies, to join forces to try to obtain a better knowledge of the social and economic problems determining the supply of skins. The objective of this note is to promote a constructive discussion process among interested parties.

Monitoring of socio-economic factors that affect skin supply and policy analysis: Information gathering and policy analysis. The following essential information needs to be gathered: origin, breed, grading, means of transportation from the place of sale to the tanneries, transportation and storage costs, price paid per lot of skins, taxes, and date of purchase, etc. Because this information will be continuously stored on computer, time series data can provide relationships with seasonality in feed production as well as seasonality in the labor force. Seasonal patterns are extremely important for a province such as Balochistan where rainfall and its variability govern the farming systems. In addition, seasonality in the labor force or availability of transportation can determine distribution bottlenecks in Balochistan and other provinces. It will be necessary to develop statistically a common baseline to integrate the data for raw skins and leather which are available in different units (numbers of raw skins and areas of finished leather, respectively).

Because the value of the skins represents only a small proportion of the total value of the animals (for example, 9 percent in Balochistan), producers, wholesalers, and butchers perceive the skins as a by-product of meat sales. This is what determines the supply inelasticity of skin prices. It is essential to find mechanisms whereby the tanners can convey the message that better quality skins fetch higher prices. Grading systems and public auctions could be extremely useful. It is necessary to gather information about the marketing systems and how livestock prices are related to the prices of by-products. In Pakistan the retail price of mutton is fixed; thus, any incentives for the producer must come from the potential gains in by-products.

Information about the market for raw skins, leather and leather products in the international markets is also indispensable for assessing the potential

opportunities to expand the leather industry or for diversifying it according to expected market forces. FAO (1992) reports that a quantitative econometric model was used to assess the likely effect on trade of a relaxation of restrictions on trade. It should be studied whether or not trade liberalization, in general, "would lead to lower consumer prices and increased consumption of leather products, and hence to increased demand and higher prices of raw materials" (FAO, 1992). This seems to be extremely relevant in the light of the current imports of raw materials to Pakistan, and their likely increase in the future.

A joint effort. Information gathering and analysis can be achieved, provided there is cooperation among institutions that already have some expertise on different aspects of skin production and marketing, skin processing, leather and leather products. The proposed scheme involves a relationship between government entities and the private sector. The Pakistan Agricultural Research Council (PARC) has a Sheep and Wool Coordination Unit in Islamabad and an Agricultural Economics Section operating in the Arid Zone Research Institute (AZRI) in Quetta. Scientists in AZRI have studied the seasonal changes in livestock prices as they relate to liveweight, breed, sex, body condition and age of the animals, and the marketing of skins in Balochistan (see previous section). Scientists from the Leather Research Center (PCSIR) and the Leather Products Development Organization could provide valuable help in understanding the social and economic factors involved in the processing and handling of skins and hides. The Pakistan Tanners Association (PTA) could provide access to information about the skins purchased from different parts of the country and overseas, and perhaps, grant scholarships for Pakistani nationals interested in conducting graduate research in areas of livestock and leather economics.

The partnership of government agencies and the private sector could have a beneficial effect on the small ruminant component of the livestock subsector. A solid data base on livestock, meat, skins, wool and leather would be developed, which would facilitate comprehensive studies into the dynamics of the meat, wool and leather industries.

Financial support: Khan (1967) suggested the creation of a Leather Research Institute to support the leather industry in technology development and day-to-day problem solving. The benefits of financial support to this suggestion, creation of the Leather Research Center (PCSIR), are irrefutable after almost 25 years. However, further growth of the leather industry in Pakistan should not only rely on the technological improvements of leather processing but it should be complemented with knowledge of socio-economic factors which determine the supply of skins. There is a need for developing a Livestock and Leather Policy Institute (offered as a possible name) to track domestic and international supply and demand of raw skins and leather and leather goods. Specialized staff would be trained in the areas of econometrics, marketing, livestock and leather policy analysis and international trade, and they could provide a valuable service to the private sector and government decision makers.

It is not proposed to finance academic research; rather, to finance applied research with a view towards economics and business administration. This is needed in order to avoid more dependence on imported raw skins and to stimulate the vertical integration of the leather and meat industries (Shuja-Uddin-Siddiqi, 1992). It is suggested that Rs1.5 million per year, less than 0.015 percent of the value of annual exports of leather and leather products, should be invested in this joint applied research effort (salaries, equipment and data acquisition) which would help to ensure sustainable growth of the leather industry.

Competition in the international leather market is likely to increase, and the competitive advantage of the Pakistani industry depends on timely decisions that will have a long-term impact on its sustainability. Thus, the small cost involved in financing applied research will be more than offset by the development of Pakistan's competitive advantage.

Imran Ali: principal investigator

The Economics and Risk Analysis of Water-harvesting (Protocol E04)

The most limiting factor for crop production in rain-fed areas of Balochistan is the skewed distribution of rainfall in both time and space (Kidd *et al.*, 1988). Annual rainfall in highland Balochistan ranges from 150 to 225 mm in the southern districts of Khuzdar and Kalat and 275 to 350 mm in the northern districts of Loralai and Zhob. Crop production in non-irrigated areas is either totally dependent on rainfall (*khushkaba*) or dependent on run-off water collected from non-cultivable land to supplement rainfall (*sailaba*).

In an attempt to demonstrate better utilization of rain water, AZRI has been growing cereals, lentils and forage legumes under water-harvesting techniques in highland Balochistan since 1986. The preparation of small catchment basins on rainfed valley bottom soils represents a low-cost method of generating run-off and increasing crop yields within the cropped areas (Rees *et al.*, 1991). The run-off area is formed by ploughing, cultivation with a tinned implement to physically disintegrate the soil aggregates, levelling with a wooden beam and sprinkling the soil with water - the impact of the drops seals the soil surface into a crust. The proportions of water-catchment area and cropped area investigated by AZRI scientists are as follows: for the control treatment the entire area is occupied by the crop; in the 1:1 treatment half of the area is used for water-catchment and the other half for planting; lastly, in the 2:1 treatment, two thirds of the area is used for water-catchment and one third for planting.

The objectives of this study were two-fold:

- to compare water-harvesting techniques with the existing farming practices, and
- to determine to what extent the economic benefits are increased and their associated risks are decreased.

The economics of water-harvesting: The economic feasibility of water-harvesting depends on the following inter-related questions:

- whether or not the cropped area of a water-harvesting treatment yields more than both cropped and catchment areas without any land treatment (control). For example, does the 1:1 treatment yield more than double the yield of the control or does the 2:1 treatment yield more than three times the yield of the control?
- whether there are reductions in the fixed and variable costs when the proportions of cropped-to-catchment areas are changed, and
- whether there is an increase in the price of the outputs (grain and straw) relative to the costs of inputs, or a decrease in the cost of inputs relative to the price of outputs for the different treatments.

The rationale behind the first question is that there are foregone benefits if no crop is planted in the catchment area, and these benefits need to be accounted for. Data on land tenure (Nagy and Farid Sabir, 1987; Masood *et al.*, 1988; Farid-Sabir *et al.*, 1991) do not suggest that *khushkaba* land is unlimited, and the only information available on cropping intensity in highland Balochistan is not very complete (Rees *et al.*, 1987, Table 3, p. 9). This weakens the argument that the opportunity cost of not using *khushkaba* land is very low or negligible.

The trials: Six seasons of wheat trials (1986/87 to 1991/92) and four seasons of barley trials (1988/89 to 1991/92) were used in this study. The local wheat landrace was planted during the first two seasons, Pak-81 was planted in the two following seasons, Punjab-85 was used in the fifth season and Pak-81 was used again in the last season. The local barley landrace was planted in 1988/89 and *Arabi Abiad*, a Syrian landrace, was used in the last three seasons. A seed rate of 100 kg/ha was used for both wheat and barley. Wheat and barley yields for both the 1:1 and 2:1 treatments were adjusted for the total area, that is the cropped-plus-catchment area, to account for the opportunity cost of not planting in the catchment area (ICARDA, 1989, p. 42). Yields of wheat and barley grain and straw, and rainfall during the trials, are reported elsewhere (Rodríguez *et al.*, 1993).

Partial Budgets: Partial budgets were developed for each crop, season, location and trial to calculate the benefits and the costs associated with the treatments. They reflect the prices of the traditional farming practices in rainfed areas of highland Balochistan where camels are used for ploughing, harvesting and threshing (AZRI/ICARDA, 1992). Budgets for the individual trials are reported by Rodríguez *et al.* (1993).

Results and Discussion: wheat: The control treatment showed a net benefit lower than the 1:1 treatment but higher than the 2:1 treatment and the coefficients of variation of the net benefits of the 1:1 and 2:1 treatments were slightly lower than the control (Table 4.3). Comparing the averages and coefficients of

Table 4.3. Gross benefits, costs and net benefits (Rs/ha) of wheat grown using different water-harvesting treatments for the period 1986-92 in highland Balochistan

		All seasons		Relative to control (%)	
Treatment		Avg[1]	CV[1]	Avg	CV
Control	GB[2]	1185	59		
	TC[2]	839	19		
	NB[2]	346	177	100	100
1:1	GB	986	67		
	TC	564	20		
	NB	422	138	122	78
2:1	GB	669	63		
	TC	438	19		
	NB	231	160	67	90

[1]Avg=average; CV=coefficient of variation (%).
[2]GB=gross benefits; TC=total costs; NB=net benefits.

variation of the net benefits showed that the 1:1 treatment had 22 percent higher net benefits than the control with a 22 percent reduction in the coefficient of variation. The 2:1 treatment had 33 percent lower net benefits than the control and reduced the variation of the net benefits by 10 percent.

Results and Discussion: barley: The control treatment showed the highest net benefit and the net benefit of the 1:1 treatment was higher than the 2:1 treatment (Table 4.4). The 1:1 treatment had a 31 percent lower net benefit than the control and increased by 6 percent the variation in net benefits. The 2:1 treatment had 14 percent lower net benefits than the control and a 19 percent higher variation.

Table 4.4. Gross benefits, costs and net benefits (Rs/ha) of barley grown with different water-harvesting treatments for the period 1988-92 in highland Balochistan.

Treatment		All seasons		Relative to control (%)	
		Avg[1]	CV[1]	Avg	CV
Control	GB[2]	1311	38		
	TC[2]	890	14		
	NB[2]	421	94	100	100
1:1	GB	862	41		
	TC	663	27		
	NB	199	99	69	106
2:1	GB	721	50		
	TC	470	16		
	NB	251	118	86	119

[1]Avg=average; CV=coefficient of variation (%).
[2]GB=gross benefits; TC=total costs; NB=net benefits.

Economic results show that, in spite of the higher yields and net benefits of barley compared to wheat, wheat had a better response to the water-harvesting treatments than barley for the 1:1 treatment. Water requirements for barley are lower than wheat, which makes it more suited to lower rainfall areas than wheat, and barley has a higher water-use-efficiency than wheat. Therefore, a better response of barley had been expected. This apparent contradiction may possibly be due to a gradual decrease in water-use-efficiencies above the critical minimum water requirement.

A major assumption in this economic analysis is that the local landraces and improved varieties have the same response to additional water so that the main treatment effect being measured is the overall crop response to additional water harvested. However, the relative responses of the local landraces and improved varieties of wheat and barley to above average levels of rainfall (above 250 mm) under the conditions that prevail in highland Balochistan, remains unclear. The water-use-efficiency coefficients estimated by Rees *et al.* (1989a, 1989b) for wheat and barley were derived from data where only 28 percent of the observations had a water-availability-index (soil water at planting plus rainfall during the rest of the season) between 250 and 350 mm. Given the additional water collected

in the catchment areas, it would be worthwhile to estimate the response of these local landraces and improved varieties to above-average moisture supplies.

Water-harvesting treatments had a positive impact in the harvest index of the cereals across all seasons. The harvest index of wheat increased from 20 percent in the control to 24 percent in the 1:1 treatment but declined to 21 percent in the 2:1 treatment. Barley had a harvest index of 20 percent in the control which increased to 32 percent in the 1:1 treatment. But it declined to 18 percent in the 2:1 treatment. These figures are relevant when considering the effects on the availability of fodder and grain for animal and human consumption, or the relative prices of straw and grain.

The results of these wheat and barley trials suggest that there are still some technical problems which must be overcome before stable increases in crop production and net returns can be ensured; either too little water in dry seasons or too much in wet seasons is harvested and transferred to the cropped area, and only a small reduction in economic risk is achieved (Rodríguez *et al.*, 1993). Because of the adjustment for the catchment area, the yields in the 1:1 treatment need to be twice as high and for the 2:1 treatment three times as high as the control for these treatments to be superior to the traditional farming practice, assuming proportional costs for these treatments. However, the total costs for the different treatments increased more than proportionally to the cropped area i.e., the total costs compared to the control were more than a half or a third for the 1:1 or 2:1 treatments, respectively. These adjusted yields and costs compounded the low economic performance of the water-harvesting treatments in situations where land suitable for cultivation is limited. Non-technical factors, such as land tenure, availability of labor and capital to setup the catchment area, are also likely to limit the interest of farmers in these water-harvesting designs.

Nisar Ali Shah and Mohammad Afzal: principal investigators, and Imran Ali

Farmers' Perceptions of Water-harvesting Techniques (Protocol E05)

The casual observer often gets the impression that highland Balochistan has vast natural resources for its economic development. However, because of the gradual erosion of the soils, degradation of the vegetation and mining of the water reserves, the resources available and useful to farmers may be less than many people think. A burning question in the economic analysis of water-harvesting has therefore been whether or not land is a limiting factor in the *khushkaba* systems of highland Balochistan. This is particularly pertinent since the adoption potential of new water-harvesting practices depends as much on a farmer's ability to expand his area under wheat and to use part of it for water-catchment, as it does on the technical merits of the technology to improve production and yield stability, and to decrease economic risk. This question resulted in a survey of farmers' perceptions of water-harvesting being conducted in the spring of 1992. It also studied the factors limiting the agricultural activities of farmers. Some preliminary results from the survey are presented here.

Representative districts of highland Balochistan with contrasting annual rainfall were selected, from Zhob and Loralai in the north-east with 275-350 mm annual rainfall, to Khuzdar and Kalat in the south with 150-225 mm annual rainfall. The survey involved interviewing 145 farmers in these four districts. On average,

3-5 ha are used every year to grow wheat whereas farmers estimate that 13-17 ha are required to provide enough wheat flour for their family each year. This implies that, on average, the domestic production of wheat on farms in highland Balochistan only covers 25-33 percent of annual needs. Farmers were aware of traditional *khushkaba* systems and were conscious of the investment in terms of capital and labour required to build bunds to contain and divert water runoff. When the water-harvesting techniques studied at AZRI were explained to farmers and they were asked if they would adopt these techniques, one half responded positively. The frequency of farmers who responded positively was 25 percent higher in the wetter northern than in the southern areas. Of those farmers that responded negatively, one-third did not believe in water-harvesting techniques, 31 percent mentioned capital as a limiting factor, and 14 percent gave other reasons. Among these reasons were: shortage of land, the practice of dry sowing which prevents them from taking care of the catchment structures during the rainy season, concerns about flooding because their land is close to the foothills which are natural catchment areas. The rest of the farmers did not provide a specific reason for not adopting water-harvesting.

To achieve wheat self-sufficiency it would be necessary to triple or quadruple the 3-5 hectares already grown using traditional methods. If the capital and labour were available to do this using the 1:1 water-harvesting treatment, farmers' needs for wheat would be satisfied with net benefits 22 percent above those from traditional agriculture and a 22 percent reduction in economic risk.

Nisar Ali Shah and Mohammed Afzal: principal investigators

Collaborative Research with Other Institutions

Farming System Research Group at PARC. Staff in the Economics Section are actively involved in a diagnostic survey of the major constraints affecting production of major crops, fruits, trees, vegetables and livestock in Khad Kucha, district of Mastung. The Section helped in the preparation and pre-testing of the questionnaires and in data collection.

Agricultural Economic Research Unit (AERU), Department of Agriculture - Sariab, Government of Balochistan. Dr Usman is associated with the principal investigator at Sariab in a project entitled "Diagnosing and narrowing the yield gap of major crop, fruit and livestock enterprises in Kalat district of Balochistan on ORP model". It is a three year project funded by PARC.

Zhob Area Development Study. Dr Usman was a member of a mission of PARC scientists who visited Zhob district to survey the natural resources base, evaluate the agricultural potential of the area and suggest measures that are necessary to enhance productivity.

Future Research

The second meeting of the Dryland Resource Management Project (DRMP) in May 1993 will be a land-mark where, *inter ali*, the most viable avenues to improve rainfed agriculture in highland Balochistan will be discussed. The low annual rainfall, which often occurs in a few but very intense rainfall events, has caused soil losses which have been largely ignored by farmers who pay more attention to their subsistence needs (Khan, 1986). Rangelands have been subjected to excessive

grazing and alternative methods of resource use are not viable because the social institutions that determine them are not clearly understood, and established common property resource management practices have evolved into virtual open access systems. Furthermore, the farming systems research approach has not removed the perception that natural resources are elements in the production process. It would be desirable to view natural resources in a holistic fashion where their appropriate management determines the sustainability of agricultural systems.

After almost two years of research on livestock and skin marketing and seasonal price indices, AZRI has slowly developed expertise that seems to be in demand in other highland areas of West Asia and North Africa. Even though these areas of research are focussed towards income generation, and in appearance they ignore long-term resource utilization, they help to improve the managerial ability of those involved in livestock production and marketing. These pragmatic areas constitute the beginning of a livestock policy so needed to improve and sustain the welfare of both producers and consumers.

References

AZRI/ICARDA (Arid Zone Research Institute/International Center for Agricultural Research in the Dry Areas). 1992. High elevation research in Pakistan, the MART/AZR Project Annual Report 1991. ICARDA, Quetta. 66 pp.

FAO (Food and Agriculture Organization). 1992. ECDC Workshop on trades in hides, skins and their derived products. Pakistan Leather Trade Journal 19:51-62.

Farid-Sabir, G., M. Afzal, N.A. Shah, J.G. Nagy, J.D.H. Keatinge and A. Rodríguez. 1991. Camel survey results in highland Balochistan. MART/AZR Research Report. No. 66, ICARDA, Quetta.

GOP (Government of Pakistan). 1991a. Economic survey 1990-91. Finance Division, Government of Pakistan, Finance Division, Economic Advisor's Wing, Islamabad. 248 pp.

GOP (Government of Pakistan). 1991b. Economic survey 1990-91: statistical supplement. Government of Pakistan, Finance Division, Economic Advisor's Wing, Islamabad. 250 pp.

ICARDA (International Center for Agricultural Research in the Dry Areas). 1989. High-elevation research in Pakistan: the MART/AZR Project Annual Report for 1988. ICARDA, Aleppo, Syria. ICARDA 138-En. p. 38.

Khan, Muhammad Ali Abdul Karim. 1986. Soil erosion in Balochistan. Proceedings of the seminar on "Water Resources Development in Baluchistan", 21-23 April, 1986. Pakistan Water and Power Development Authority, Hydrogeology Project, WAPDA, Quetta. pp. 1-8.

Khan, M. Jamil. 1967. Export of finished leather and leather goods. In: Pakistan Society of Leather Technologists. Pakistan Leather Yearbook 1966. Karachi, Pakistan. pp. 147-157.

Khan, B.R., Thomson, E.F. and A. Rodríguez. 1992. AZRI Research Plans for 1992/93. MART/AZR Project Research Report No. 77, ICARDA, Quetta. 89 pp.

Kidd, C.H.R, D.J. Rees, J.D.H. Keatinge, F. Rehman, A. Samiullah, and S.H. Raza. 1988. Meteorological data analysis of Balochistan. MART/AZR Research Report No. 19, ICARDA, Quetta.

Mahmood, A. and F. Walters. 1990. Pakistan Agriculture. Directorate of Agricultural Policy and Chemonics International Consulting Division, Economic Analysis Network Project. Government of Pakistan and the United States Agency for International Development. 183 pp.

Masood, M.A., M. Afzal, J.G. Nagy and S.M. Khan. 1988. Agricultural and related statistics of upland Balochistan. MART/AZR Research Report No. 20, ICARDA, Quetta.

Nagy, J.G., G. Farid Sabir, N.A. Shah, M. Afzal, D.J. Rees and J.D.H. Keatinge. 1989. Barley production and its scope for improvement in the high elevation rainfed farming systems of Balochistan. MART/AZR Research Report No. 26, ICARDA, Quetta.

Nagy, J.G. and G. Farid Sabir. 1987. Household agricultural production systems survey results. MART/AZR Research Report No. 7, ICARDA, Quetta.

Rees, D.J., J.G. Nagy, S.H. Raza, K. Mahmood, B.A. Chowdry, and J.D.H. Keatinge. 1987. The dryland arable farming system of upland Baluchistan: a case study. MART/AZR Research Report No. 5, ICARDA, Quetta.

Rees, D.J., A. Samiullah, M. Islam, Z. Qureshi, and S.H. Raza. 1989a. Rainfed crop production systems of upland Balochistan. 1. Wheat (*Triticum aestivum*). MART/AZR Research Report No. 51, ICARDA, Quetta.

Rees, D.J., M. Islam, F. Rehman, A. Samiullah, and S.H. Raza. 1989b. Rainfed crop production systems of upland Balochistan. 1. Barley (*Hordeum vulgare*). MART/AZR Research Report No. 52, ICARDA, Quetta.

Rees, D.J., Z.A. Qureshi, S. Mehmood, and S.H. Raza. 1991. Catchment basin water harvesting as a means of improving the productivity of rain-fed land in upland Balochistan. Journal of Agricultural Science 116:95-103.

Rodríguez, A., I. Ali, M. Afzal, and N.A. Shah. 1992. Marketing of goat and sheep skins in highland Balochistan, Pakistan. MART/AZR Project Research Report No. 76, ICARDA, Quetta.

Rodríguez, A., N.A. Shah, M. Afzal, U. Mustafa and I. Ali. 1993. Economics of water-harvesting trials with cereal crops in highland Balochistan. MART/AZR Project Research Report No. 78, ICARDA, Quetta.

Shuja-Uddin-Siddiqi. 1992. Prospects of quantitative and qualitative improvement of hides and skins through an integrated approach to meat processing industry. Pakistan Leather Trade Journal 19: 51-62.

Siddiqui, K.A. 1962. Marketing of hides and skins in Pakistan. In: Pakistan Society of Leather Technologists. Pakistan Leather Year Book 1962. Karachi, Pakistan. pp. 47-50.

Chapter 5

AGRONOMY RESEARCH[1]

Introduction

The agronomy research trials are conducted under rainfed conditions, the local name being "kushkaba", where no run-on from outside flows on to the cropped area.

The main objectives of the field trials carried out in 1991/92 were to:

- continue the catchment-basin water-harvesting trials started in 1986/87, at existing and new sites with the addition of the 3:1 treatment with buffer zone,
- measure the effects of strip-cropping using strips with different ratios of cropped-to-catchment areas on crop production under rainfed conditions,
- evaluate the yields of improved barley lines (W12291/W12269, Arabi Abiad, Wadi Hassa, Arabi Aswad and Harmal) under rainfed conditions and
- increase the seed of improved varieties of cereals, forages and lentils.

K.N. Barbar, Head, Agronomy Section; **Muhammad Islam and Zahid Ali Qureshi**

Climatic Conditions

Table 5.1 lists the trial sites, altitudes and monthly rainfall recorded during the 1991/92 cropping season. Rainfall from July to December 1991 was insufficient to allow planting of crops in early winter. But it was plentiful from late December 1991 until May 1992, particularly in April. The rainfall season was therefore rather short but good and this caused a severe crust problem in January. There were no serious late frosts to damage the spring plantings but desiccating winds in April caused some shrivelling of grain during maturation.

Water-harvesting research

The agronomy trial sites are located close to Quetta at Dasht, Kolpur, Mastung and Spezand. The sites usually have gentle slopes of 0.5 percent. The soils, classified under the FAO system as alluvial yermosols, are alkaline with high lime and low contents of phosphorus and nitrogen. 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 rain water so that run-off starts soon after the first shower. In addition, after drying out, the surface of the cropped area forms a crust which becomes very hard and severely impedes seedling emergence. Ben-Hur *et al.* (1985) also reported that the presence of a crusted soil surface due to rainfall is a common feature of many soils, particularly in arid and semi-arid regions. Due to the slow rate of infiltration through such hard crusts, the proportion of rainfall which runs off the soil surface from the subsequent showers is greater.

---

[1]This chapter was written by staff of the Agronomy Section and edited by E.F. Thomson.

Table 5.1. Monthly rainfall (mm) at agronomy trial sites in 1991/92.

	Sites (altitude, m)			
	Mastung (1650)	Spezand (1775)	Quetta (1700)	Loralai (1340)
July (1991)	0.0	1.5	0.0	0.0
August	0.0	0.0	0.0	14.6
September	0.8	0.0	12.3	1.3
October	1.3	0.0	0.0	0.0
November	9.4	12.4	6.1	0.0
December	15.7	16.0	22.3	0.0
January (1992)	40.3	60.9	46.6	11.4
February	63.1	58.0	58.1	21.6
March	52.5	54.9	48.0	45.4
April	77.3	64.9	132.2	116.8
May	20.3	7.4	6.1	25.7
June	0.3	1.5	0.0	1.5
Total (mm)	281.0	277.5	331.7	238.3

These soil characteristics provide the conditions to adopt water-harvesting systems as a way to increase crop yields.

Catchment-Basin Water-Harvesting (CBWH): Water-harvesting can be defined as the collection and concentration of run-off water in the cropped area from the modified soil catchment area. The probability of rainfall occurrences of more than 200 mm during the cropping season, October to May, is very low. This situation indicates that 100 mm or more water needs to be harvested from catchment areas to fulfil the water requirements of a wheat crop. (The studies on CBWH started in 1985/86 on wheat and in 1987/88 with barley.)

The replicated water-harvesting layouts established in previous years at Kolpur, Dasht, Mastung and Spezand were used again. These have an additional buffer zone planted with saltbush to allow run-off of any excess water collecting in the cropped area. This can otherwise lead to water-logging and damage to crops. At each site there are four treatments, each on plots of 20 x 60 m: 1) control, in which 75 percent of the area is cropped and 25 percent is used for the buffer zone; 2) 1:1, in which half of the plot is the catchment area and half the cropped area 3) 2:1, in which half of the plot is the catchment area, 25 percent is the cropped area and 25 percent the buffer zone; 4) 3:1, in which 60 percent is the catchment area, 20 percent the cropped area and 20 percent the buffer zone. In all trials the slope of the catchment area is 0.7 to 1.0 percent. The catchment areas were originally prepared by ploughing with a tractor-mounted mouldboard plough, pulverizing and levelling the soil with a tractor-mounted heavy wooden plank, and sprinkling with water to create a surface crust which facilitates run-off. Local wheat and Arabi Abiad, a Syrian landrace of barley, were planted at each site as main plots and these were split to allow manure and fertilizer (Nitro-phos) treatments. Crop yields are only reported from Mastung and Dasht since at Spezand and Kolpur crops were too poor to harvest.

In both the trials at Mastung, crop yields in the three water-harvesting treatments were not significantly (P>0.05) better than the control. The wheat and barley TDM and grain yields are presented in Table 5.2. Barley yielded more TDM and grain than wheat. Yields of both wheat and barley were not improved by the application of manure or fertilizer (P>0.05). This is a similar result to that in previous years.

Table 5.2: Wheat and barley TDM and grain (G) yields (kg/ha) with different water-harvesting treatments at Mastung, 1991/92

	Mastung 1				Mastung 2			
	Wheat		Barley		Wheat		Barley	
	TDM	G	TDM	G	TDM	G	TDM	G
Control	713	82	1025	186	622	70	901	128
1:1	798	107	1134	274	907	96	1217	294
2:1	1004	229	1655	313	956	115	1362	263
3:1	1215	210	1992	594	1014	141	1326	289
SEM	67.1	22.4	67.1	22.4	63.9	17.8	63.9	17.8
LSD(5%)	ns	ns	ns	ns	ns	ns	ns	ns

The results for the two water-harvesting trials at Dasht are summarized in Table 5.3. The water-harvesting treatments gave similar (P>0.05) crop yields to the controls. Wheat and barley have different water requirements and therefore their behaviour contrasted in the different water-harvesting treatments. Barley is more drought resistant than wheat and has earlier maturity. These attributes made it more productive than wheat in both the water-harvesting trials at Dasht. At this site neither manure or fertilizer application resulted in higher yields over control treatments (P>0.05).

Table 5.3: Wheat and barley TDM and grain (G) yield (kg/ha) with different water-harvesting treatments at Dasht, 1991/92

	Dasht 1				Dasht 2			
	Wheat		Barley		Wheat		Barley	
	TDM	G	TDM	G	TDM	G	TDM	G
Control	578	114	612	135	404	126	828	203
1:1	503	132	605	148	622	169	860	192
2:1	1498	343	2329	613	749	267	720	307
3:1	1937	567	1868	517	719	196	900	287
SEM	121.0	39.0	121.0	39.0	47.4	12.5	47.4	12.5
LSD(5%)	ns	ns	ns	ns	ns	ns	ns	ns

Strip-cropping trial at Mastung

Strip-cropping and strip-farming have been used for many years in a range of situations to control both wind and water erosion on cultivated lands. These are systems in which crops are planted in narrow strips across the slope of the land. They are typically used on slopes of less than two percent. During the 1991/92 season, the first strip-cropping trial was conducted at Mastung under *khushkaba* conditions. There were three treatments, with different catchment-to-strip widths (in m): 4:4, 4:2, 6:2. The cropped area was planted with the improved barley W12291/W12269. The results, shown in Table 5.4, indicate that crop yields under the different treatments were similar in this initial trial.

Table 5.4: TDM and grain yields (kg/ha) of barley in strip-cropping trial at Mastung, 1991/92

Treatments	TDM	G
4:4	944	175
4:2	1071	257
6:2	1093	217
C.V.	20	25
LSD(5%)	ns	ns

Performance of promising barley germplasm at Mastung

Five exotic barley genotypes, selected by the Germplasm Section, were tested for total dry matter (TDM) and grain yield under rainfed conditions at Mastung. They were planted in late December 1991 in plots of 4 x 60 m. Four random samples of 1 m^2 were taken from each genotype for the calculation of TDM and grain yield. These samples were considered as replicates in the statistical analysis. Well distributed rains were received during the growing season (Table 5.1).

The genotypes of barley W12291/W12269 and Wadi Hassa yielded significantly ($P<0.05$) more TDM than Harmal and Arabi Abiad. Seed yields of Wadi Hassa were significantly ($P<0.01$) higher than Arabi Aswad, Arabi Abiad and Harmal. However, seed yields of W12291/W12269 and Wadi Hassa were not significantly different (Table 5.5). Ahmad *et al.* (1991) reported good performance of these genotypes when planted in spring in highland Balochistan. The genotypes W12291/W12269 and Wadi Hassa have now shown good potential for cultivation as a spring sown crop for the rainfed areas of highland Balochistan.

Table 5.5: TDM and grain yields (kg/ha) of promising germplasm of barley grown under rainfed conditions at Mastung, 1991/92

Genotype	TDM	Grain yield
W12291/W12269	6333[A1]	1762[ab1]
Wadi Hassa	6333[A]	2094[a]
Arabi Aswad	5000[AB]	1387[bc]
Harmal	4000[B]	1019[c]
Arabi Abiad	4600[B]	1279[bc]

[1]Capital and small letters show differences at $P<0.05$ and $P<0.01$, respectively.

References

Ahmad, S., Irshad Begum, S.A. Jalil, M.A. Khan, B.R. Khan and A.Y. Allan. 1991. Germplasm evaluation in arid highlands of Balochistan: annual report of the germplasm research group. MART/AZR Project Research Report No. 73, ICARDA, Quetta, Pakistan.

Ben-Hur, M., I. Shainberg, R. Keren and M. Gal. 1985. Effect of water quality and drying on soil crust properties. Soil Science 49: 191.

Chapter 6

GERMPLASM RESEARCH[1]

Introduction

In highland Balochistan water and cold stresses are an inevitable consequence of the arid and semi-arid continental Mediterranean climate. They are coupled with other abiotic and biotic stresses that affect crops at critical stages of growth. The Germplasm Section has therefore the following objectives:

- to select and release superior, well-adapted, disease-free and disease resistant crop species, lines and genotypes suitable for growth under rainfed conditions. (Better genotypes of alternative crops will give farmers an opportunity to diversify away from wheat which is the main crop cultivated in highland Balochistan.) and

- to investigate the potential of producing additional feed in the highlands from new forage crops and crop residues from higher-yielding food crops grown under rainfed conditions.

This section gives the highlights of the germplasm research conducted during 1991/92. Full details of the results are published elsewhere (Khan *et al.*, 1993).

Mohammad Anwar Khan: Head, Germplasm Section; **Irshad Begum, Sarfraz Ahmed and S.A. Jaleel**

Climatic conditions

The 1991/92 cropping season was generally good in terms of precipitation at all the test sites and the humid and warm conditions resulted in a yellow rust epidemic for the third year in succession in highland Balochistan. This resulted in an ideal environment for screening material against yellow rust (*Puccinia striiformis*). At Quetta insufficient rain was received during the autumn to allow planting without a pre-planting irrigation (Table 6.1) but the rainfall conditions were favourable for the spring planting. Winter temperatures were not low enough to cause cold and frost mortality of plants and therefore all the genotypes under test survived the winter months.

Severe hail storms struck Loralai and Kan Mehtarzai just before harvesting. As a result only two forage trials were harvested at Kan Mehtarzai. At Loralai both cereals and food and forage legumes were damaged either completely or partially, depending upon growth and maturity type.

Methodology

Four test sites were used during the 1991/92 season: ARI-Sariab (Quetta) (altitude 1850 m), Kalat Ahmad Abad (1850 m), Killi Bokhara (Loralai) (1340 m),

---

[1]The staff of the Germplasm Section deserve credit for writing much of this chapter which was edited by E.F. Thomson.

Table 6.1. Climatic data at ARI and Kalat, 1991/92[1]

	ARI (Quetta)			Kalat(Ahmad Abad)[2]		
Month	Total rainfall (mm)	Mean temp.[3] (°C) Max.	Min.	Total rainfall (mm)	Mean temp.[3] (°C) Max.	Min.
July	1.5	35.2	16.9	-	-	-
August	0.0	35.2	18.3	-	-	-
September	13.7	30.6	11.0	-	-	-
October	0.0	23.5	3.2	-	-	-
November	9.4	10.1	1.3	-	-	-
December	17.8	14.7	1.2	-	-	-
January	61.0	11.4	-0.5	-	-	-
February	46.4	13.4	-0.4	58.4	12.0	-0.9
March	41.9	15.9	2.0	29.0	14.2	1.2
April	92.4	20.0	7.3	33.4	18.8	6.9
May	15.0	25.3	10.5	158.0	27.0	10.9
June	2.3	33.8	13.4	0.0	31.6	13.2
Total (mm)	301.4			278.8 (February to June:		
Irrg. (mm)	50[4](approx.)			50[4] - cropping season)		

[1]The staff of the Agronomy Section are thanked for collecting the data for the Loralai site (see page 36).
[2]Data provided by the meteorological station at Kalat. Only data from the February - June cropping season shown as crops spring sown.
[3]Screened air temperature at 1.5 m.
[4]Applied as one supplemental irrigation before sowing since insufficient moisture available for sowing.

and Kan Mehtarzai (2250 m). They represent the main agro-ecological zones and environmental conditions found in highland Balochistan.Autumn and spring planting times are chosen according to the practices of the local farmers. Autumn planting takes place from mid-October to mid-November at Quetta, Loralai, and Kan Mehtarzai. At Quetta, trials are planted after applying a pre-planting irrigation of about 50 mm. At Loralai, crops are planted into soils containing residual moisture from the monsoon rains. At Kan Mehtarzai the crops are planted after receiving sufficient rains in November.

Spring trials are conducted at Quetta and Kalat for selecting short duration, disease resistant and drought tolerant genotypes. At Quetta crops are sown in early February after sufficient winter rains and at Kalat crops are planted in the last week of February after a pre-soaking irrigation.

Randomized complete block designs are used for yield trials; each entry has four-to-six rows per plot at different sites. Rows are 5 m long and row-to-row distance is 25 cm. Yield trials have three replicates except at ARI-Sariab Quetta where only two are used due to a shortage of land. NPK fertilizer rates are 20:20:0 for wheat, barley, lentil and forages and *Rhizobium* inoculum is applied to food and forage legumes. Harvesting takes place between mid-May and

late June depending upon the varying dates of crop maturity at the different sites.

The following parameters are recorded before harvesting: growth habit (erect, prostrate, intermediate), cold tolerance (scale 0-5), days to heading (when 50 percent of crop has headed, expressed as days from sowing), plant height, number of spikelets per spike (only in barley), tillers per m^2, and yellow rust disease resistance (Modified Cobb Scale). Production data measured are: total dry matter (TDM) and grain yield, and 1000 seed weight. Harvest index (HI) is the proportion of grain in the total dry matter yield (TDM). The two middle rows of plots are used to record data at all sites. The MSTAT.4C program is used for data analysis.

Research Highlights

Seed multiplication during 1992/93. A particular effort was made during the 1991/92 season to produce more seed from promising lines for multiplication during 1992/93 (Table 6.2).

Table 6.2. Seed of selected genotypes sown for multiplication and distribution Balochistan for the 1992/93 season (kg)

Genotype	ARP (GOB)	EADA (Khuzdar)	Sur Tal (GOB)	DG (GOB)	Loralai (FL)	Kanak (FL)	AZRI	Total (kg)
Bread Wheat								
Gerek	40	-	10	60	135	-	3	248
ICW1471	40	-	10	25	75	-	6	156
Barley								
39-58	80	-	30	60	140	-	2	312
Arabi Abiad	80	20	-	-	70	-	-	170
Lentil								
ILL 5865	1	-	1	-	-	5	1	8
ILL 5677	1	-	1	6	-	10	1	19
Forage Legumes								
Woollypod vetch 683	1	-	25	25	-	-	2	53

Notes:
1. ARP (GOB): Adaptive Research Program of the Government of Balochistan (GOB) whose demonstration-cum-research trials are planted at many sites across highland Balochistan.
2. EADA (GOB): Extra-Assistant Director, Agriculture at Khuzdar.
3. DG (GOB): Director General (Agriculture) kindly allowed AZRI scientists to plant their material along with research material.
4. Loralai (FL): at Loralai a farmer has planted the seed and the grain will be purchased by AZRI.
5. Kanak (FL): at Kanak valley another farmer has planted the seed which will be purchased by AZRI.

Resistance to yellow rust: Two lines of bread wheat, Gerek and ICW1471, proved to be resistant to the yellow rust race OE-16 of Balochistan. Moreover, the Cereal Diseases Research Institute (CDRI) of PARC in Islamabad also confirmed their resistance to the fungal disease after one year of testing in their nationwide trials, using a mixture of different races of the fungus. During 1992/93 Gerek, ICW1471 and some other AZRI selections will be inoculated again at CDRI with spores of race OE-16.

Chemical composition and baking quality: Gerek and ICW1471 were also sent for testing to the Food Technology Research Laboratories of the National Agriculture Research Center (NARC) in Islamabad. The results, summarized in Table 6.3, indicate that the protein contents of Gerek and ICW1471 are higher than the local landrace of wheat.

Table 6.3. Kernel weight and baking quality of selected genotypes of wheat

Genotype	1000 kernel weight (g)	Dry gluten (% in DM)	Protein in:	
			flour	WMF[1]
Gerek	33.4	15.8	17.6	17.7
ICW1471	33.1	12.9	12.5	14.0
Local	28.0	-	-	10.1

[1]wholemeal flour, % in DM.

Bread wheat: Bread wheat (*Triticum aestivum L.*) is the most important food crop grown in the highlands of Balochistan under rainfed conditions and most of the farmers prefer to grow it for domestic use and food security. Local wheat landraces are well adapted to the environmental stresses of the area but they are very susceptible to diseases, especially yellow rust (Ahmad *et al.*, 1990a; Mohammad, 1989) which drastically reduces yields. This makes selection for resistance to yellow rust a major aim of the Germplasm Section.

During the 1991/92 season, material in eight bread wheat trials (1026 entries) was planted in autumn and material in two advanced bread wheat trials (28 entries) was planted in spring. Out of these, 102 entries were selected for further testing and HAW-16 and CM69599 are being multiplied for seed, along with Gerek and ICW1471. All these lines show resistance to yellow rust and better production than the local landrace under the prevailing stresses in highland Balochistan. Eight potentially superior genotypes with a shorter maturity period have also been selected for spring planting and are being multiplied.

Barley: Barley (*Hordeum vulgare L.*) is the second most important crop in highland Balochistan. It is mostly grown under less favourable environmental conditions than wheat due to its better drought tolerance and yielding ability under moisture stress. It is a feed crop, used either as winter grazing or for producing grain and straw.

Recent studies on barley in highland Balochistan have shown that it is a more suitable crop than others for the area (Ahmad *et al.*, 1990b; Rees *et al.*, 1989). Therefore, efforts are being made to select exotic lines adapted to the

prevailing environmental conditions and sowing time. During the 1991/92 season 11 trials (total 496 entries) were established in autumn and two trials (total 21 entries) were established in spring. From these exotic genotypes 159 lines were selected for future testing. Another three genotypes (Di Jou 3-2-5; Rihane-03, Arabi Abiad/Emir, ICB82-1292-0AP-0AP-6AP-0AP) have entered into seed multiplication. These lines have exhibited superior performance at different locations and resistance to yellow rust.

Lentils: Lentil (*Lens culinaris*) is an important pulse crop in Pakistan but is only grown on a small area in Balochistan. This is apparently related to the small seed size of the local genotype which reduces its market price compared to large seeded lentils (Keatinge *et al.*, 1990). Introduction and selection of bold/large seeded, cold, drought and disease resistant genotypes should encourage lentil production in highland Balochistan. Such material has been identified during the last few years (Ali *et al.*, 1991). However, efforts to find more material of this type need to continue.

Material in six lentil trials (total 113) with autumn planting and in three trials (total 62 entries) with spring planting was evaluated in 1991/92. Out of these, 38 superior lines are being tested in 1992/93 and the seed of two genotypes, ILL5668 and ILL5865, is also being multiplied (Table 6.2). ILL5668 looks particularly promising after four years of multi-location testing.

Forage Legumes: Annual forage legumes have a high feeding value and they can be either grazed or harvested for grain, straw and hay. Their potential for cultivation in a Mediterranean environment has been shown (Moneim *et al.*, 1990) and some species of vetch in particular grow well under rainfed conditions in the highlands of Balochistan (Keatinge *et al.*, 1991).

Efforts continued during 1991/92 to test several species of vetch suitable for the harsh conditions of the Province. They include: *Vicia villosa* ssp. *dasycarpa*, (woollypod vetch), *V. sativa* (common vetch), *V. ervilia* (bitter vetch), *V. narbonensis* (narbon vetch) and *Lathyrus sativus* (common chickling/grass pea). In addition, the self-regenerating ability of *V. sativa* ssp. *amphicarpa*, a subterranean vetch that buries its seed, was included in the evaluation program.

Material in three trials (46 entries) with autumn planting and in three trials (307 entries) with spring planting was tested for its potential and some promising genotypes were selected for further testing. To date *V. villosa* ssp. *dasycarpa* and *V. sativa* lines have been selected for winter and *V. ervilia* for spring planting. These selected lines are better yielding than the local check, *V. villosa* ssp. *dasycarpa* selection number 683, under stress conditions. These selections are the result of five years of multi-locational trials.

Another forage legume, *Lathyrus sativus* (grass pea or common chickling), is second in importance to chickpeas in Pakistan. It is a multipurpose crop grown for centuries in Pakistan, mainly in the province of Sindh where it is used as green fodder, as a pulse crop and as a snack. Grass pea, the Matar of Sindh, Charal of Punjab and Chilo of Swat (NWFP), is a remarkably hardy crop which can tolerate both drought and flood. It is highly nutritious, palatable, widely accepted by local people and can be cultivated using low input farming practices. However, it contains an toxic component, beta-N-oxalyl-amino-L-alanine (BOAA) that can lead to lathyrism in humans.

In the highlands of Balochistan water limitation is one of the main abiotic factors affecting crop production. It is therefore important to identify crop species which have low water requirements that potentially fit into the existing farming system. For these reasons, two trials using lathyrus were conducted in highland Balochistan during the 1991/92 season. Selection will be made on the basis of the BOAA content which is being determined at NARC, Islamabad.

REFERENCES

Ahmad, S., A. Ali, B.R. Khan and J.D.H. Keatinge. 1990a. Germplasm evaluation in arid highlands of Balochistan: annual report of the germplasm research group. MART/AZR Project Research Report No. 63, ICARDA, Quetta, Pakistan.

Ahmad, S., J.D.H. Keatinge, B.R. Khan and A. Ali. 1990b. Evaluation of winter wheat germplasm for the arid highlands of Balochistan. Sarhad Journal of Agriculture 6(5): 459-465.

Ali, A., J.D.H. Keatinge, B.R. Khan and S. Ahmad. 1991. Germplasm evaluation of dual-season lentil (*Lens culinaris*) lines for the arid highlands of West Asia. Journal of Agricultural Science (Cambridge) 17:347-353.

Keatinge, J.D.H., A. Ali, B.R. Khan, A.M. Abd-El Moneim and S. Ahmad. 1991. Germplasm evaluation of annual sown forage legumes under environmental conditions marginal for crop growth in the highlands of West Asia. Journal of Agronomy 166: 48-57.

Keatinge, J.D.H., N. Buzdar, G.F. Sabir, M. Afzal, N.A. Shah and A. Ali. 1990. Lentil production in highland Balochistan: current status. Lens Newsletter 16(2): 5-8.

Khan, M.A., S. Ahmad, Irshad Begum and S.A. Jalil. 1993. Germplasm evaluation in arid highlands of Balochistan: annual report of the AZRI Germplasm Evaluation Section 1991/92. MART/AZR Project Research Report No. 80, ICARDA, Quetta, Pakistan.

Mohammad, S. 1989. Historical background of wheat improvement in Balochistan, Pakistan (1909-1980). Rachis (8): 10-12.

Moneim, A. Abd El; P.S. Cocks and Y. Swedan. 1990. Yield stability of selected forage vetches (*Vicia* ssp.) under rainfed conditions in West Asia. Journal of Agriculture Science (Cambridge) 111: 295-301.

Rees, D.J., F. Rehman, J.G. Nagy, G.F. Sabir, J.D.H. Keatinge and S.H. Raza. 1989. Barley production under suboptimal conditions in upland Balochistan: agronomic and socio-economic considerations. MART/AZR Project Research Report No. 24, ICARDA, Quetta, Pakistan.

Chapter 7

Staffing matters, Collaboration, Training, Workshops and Seminars

Staffing Matters

The staffing situation continues to be critical at AZRI although there are signs of improvement. Particularly encouraging is the evidence that staff are being rotated to and away from AZRI (Annex 2). Tables 7.1 and 7.2 below summarize the changes.

Staff leaving. Dr Jasra, the first AZRI staff member to complete a PhD sponsored under the MART project, left for PARC HQ after staying at AZRI for about 18 months instead of the three-to-four years that is expected of such staff trained under the MART project. Dr Munir, Mr Aslam and Mr Sher Mehmood were transferred to PARC since they had already served many years at AZRI. This is clear evidence

Table 7.1. Staff leaving AZRI in 1992.

Name	Grade	Section	Month joined	New posting	Type of new posting
1 Dr A. Wahid Jasra	SSO	Range	Oct (90)	PARC HQ	Regular PARC
2 Dr M. Munir	SO	Livestock	May (81)	PARC HQ	Regular PARC
3 Mr M. Aslam	SO	Agronomy	Jan (87)	PARC HQ	Regular PARC
4 Mr Sher Mehmood	SO	Agronomy	Jun (86)	PARC HQ	Regular PARC
5 Mr Nisar Malik	SSO	Agronomy	Dec (91)	WFProg.	Left PARC

to other long-serving AZRI staff that their colleagues are now being transferred away from AZRI. It also indicates the PARC policy of rotating staff between institutes and locations. Mr Nisar Malik, who was on contract at AZRI for just over one year, left for a job with the World Food Program in Quetta. These staff changes have markedly strengthened the Livestock Section but the Agronomy Section has been temporarily weakened.

Table 7.2. Staff joining AZRI in 1992[1]

Name	Grade	Section	Month joined	Previous posting	Type of contract
1 Dr Sarwat N. Mirza	SO	Range	May	NARC	Regular PARC
2 Mr Inam Ul-Haq	SO	Livestock	April	PARC HQ	Regular PARC
3 Mr M. Adel Akbar	AAE	Ag. Engin.	Dec	NARC	Regular PARC
4 Mr Ejaaz Rasool	SO	Livestock	May	GOPunjab	Contract PARC
5 Mr Riaz Hussain	SO	Livestock	Nov	UAF	Contract BOSTID

[1]In early January 1993 two more staff joined AZRI: Mr Abdul Razzaq (SO on extension, on contract with PARC), and Mr Sohail Zia (ASO in the Livestock Section funded by BOSTID).

The staffing levels at AZRI on December 31, 1992 are shown in Figure 7.1. Careful examination shows that the staffing situation is still precarious. There is only one PSO grade and one SSO grade, and three Sections are headed by staff in the SO grade. (One other PSO post is occupied although the incumbent is not assigned to a Section.) Out of the total of 21 staff in grades 16-19 presently at post, two are on contract, two are ad-hoc appointees and two are funded by BOSTID. The Extension Section is the weakest but it is planned to strengthen it

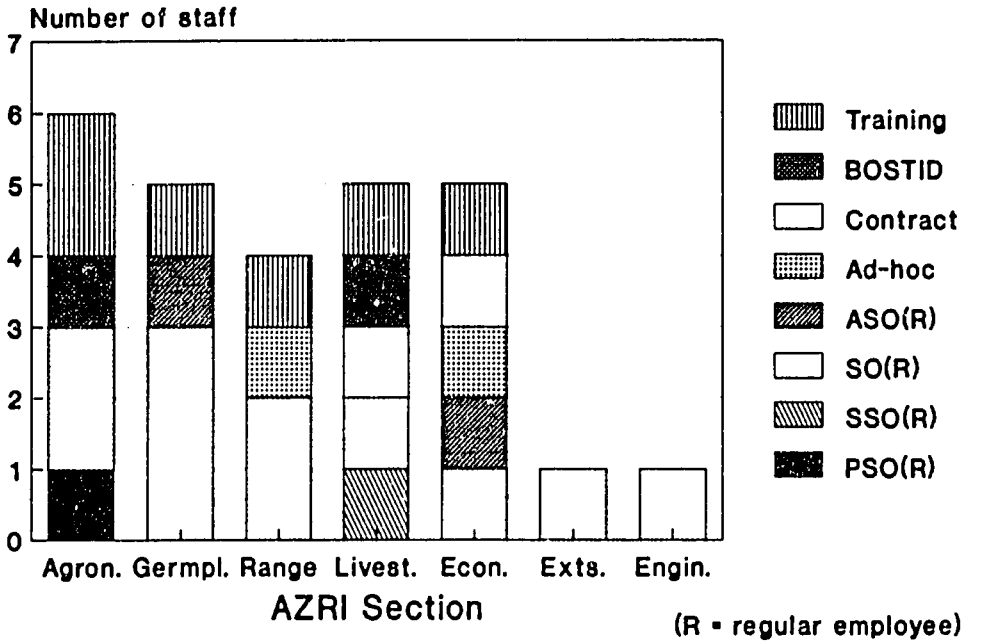


Figure 7.1. Staffing of scientific officer grades (BPS 19-19) at AZRI on December 31, 1992. (Excluding Director)

by appointing new staff to implement the saltbush campaign. The arrival in December of an agricultural engineer, Mr Adel Akbar who worked previously at the Farm Machinery Institute of NARC, is a welcome development.

There will be a serious staff gap at AZRI for the next one-to-two years until more long-term trainees return. Even then AZRI will be staffed by relatively junior scientists.

AZRI/NARC Collaboration

Closer links with NARC scientists was a major theme during 1992 and some progress was made. The primary reason for improving these links is to use the large body of scientific expertise at NARC to fill gaps in the expertise at AZRI. Also, closer AZRI-NARC collaboration is seen as a morale-booster for AZRI scientists who suffer from a feeling of isolation.

The following section outlines the areas of collaboration suggested at the May 31, 1992 AZRI-NARC Coordination Meeting held at NARC.

1. Mineral balance in saltbush fed sheep (ASI). A willingness to collaborate was expressed and one parasitologist from the Animal Science Institute (ASI) gave a

short training course at AZRI in July 1992. Samples of blood serum were also sent in October to ASI for mineral analysis but only slow progress is reported towards getting the samples analysed.

2. Yellow rust in wheat (CDRI). Collaboration with the Crop Diseases Research Institute (CDRI) seems to be quite good, with one set of wheat germplasm being screened for resistance to yellow rust during the 1991/92 season. Material has been sent again this season.

3. Modification of the camel-planter (FMI). In December an agricultural engineer was transferred from the Farm Machinery Institute (FMI) to AZRI. Among his numerous duties, this engineer will also work on the camel-planter.

4. Development of AZRI range herbarium (RRI). No progress has been made on this aspect or with the Range Research Institute (RRI) in general. It is one of the most important institutes at NARC that should be collaborating with AZRI, especially since the Range Section at AZRI is so weak in terms of manpower. Renewed efforts will be made in 1993 to get some collaboration started.

5. Development of a dewinger for fourwing saltbush seed (FMI). A dewinger has been manufactured thanks to the efforts of Dr Sulaiman Hamid and FMI staff.

6. Measurement of run-off in water-harvesting trials (WRRI). There have been no further contacts between AZRI and the Water Resources Research Institute (WRRI) since the May meeting.

7. Measuring impact and adoption potential of technologies (Social Sciences Institute - SSI). Efforts will be renewed in 1993 to strengthen links between social scientists at AZRI and SSI.

AZRI/ICARDA Linkages

There has been a strengthening of the linkages between AZRI and ICARDA scientists during 1992. Evidence of this is the increased number of ICARDA scientists visiting AZRI, as shown below.

Planning Meeting: The May 11 planning meeting held in the Serena Hotel, Quetta (the visitors were in Quetta for about four days on average):

- Dr R. Booth (Assistant Director General, International Cooperation)
- Dr J. Keatinge (Regional Coordinator, ICARDA Highlands Region)
- Dr M. Jones (Leader, Farm Resource Management Program - FRMP)
- Dr E. Bailey (Economist (FRMP) and ICARDA Project Officer)
- Dr T. Oweis (Water Harvesting specialist - FRMP)
- Dr T. Pain (CIMMYT/ICARDA Wheat Breeder - High Elevations)
- Dr O. Mamluk (Cereal Pathologist - Cereal Program)
- Dr A. Rodríguez (Resident MART/AZR Advisor, Agricultural Economics)

Small Ruminant Workshop: The December Small Ruminant Workshop (one week including field trip):

- Dr J. Keatinge (Regional Coordinator, ICARDA Highlands Region)
- Dr T. Treacher (Livestock Scientist, Pasture, Forage and Livestock Program)
- Dr A. Goodchild (Ruminant Nutritionist, Pasture, Forage and Livestock Program)

- Dr W. Sarraj (Training Scientist, Pasture, Forage and Livestock Program)
- Dr A. Rodríguez (Agricultural Economist, Farm Resource Management Program)

Other ICARDA visits: Other visits included:

- Dr T. Oweis, to see water-harvesting research (5 working days in November)
- Dr A. Rodríguez, to work with Economics Section (18 working days in November and December)

AZRI Visitors to ICARDA headquarters: Further evidence of the strengthening of linkages between AZRI and ICARDA is the increasing number of visits of AZRI staff to ICARDA HQ. In 1990 and 1991 no AZRI staff made such visits although in June 1991 Mr Sarfraz Ahmed attended an ICARDA organized workshop in Turkey. In May/June 1992 Dr S. Rafique (SSO, Head, Livestock Section) spent four weeks with scientists of the Pasture, Forage and Livestock Program at ICARDA HQ as a visiting scientist. It had been planned to send Dr Wahid at the same time but he was transferred to PARC HQ so his visit was canceled. Plans have been made to send at least five AZRI staff to ICARDA HQ as visiting scientists, trainees, workshop participants in the first half of 1993.

Training

Long-term training: Table 7.3 lists the AZRI long-term trainees (LTT) who completed degrees under the MART project and Table 7.4 lists the LTTs who are currently completing their courses and research for higher degrees. Four LTTs have so far completed their degrees under MART and two of them are posted away from AZRI.

Table 7.3. Long-term trainees who have completed their degrees under MART.

	Degree	University	Return to post	Place of post	Section/Grade Designation
1. Abdel Wahid Jasra[1]	PhD	OSU	10/1990	PARC	Dep. Dir/SSO
2. Anwar Khan	MSc	MSU	3/1991	AZRI	Germpl./SO/Head
3. Babar Raza Kazi	MSc	MSU	1/1991	AZRSS-Umerkot	Dep. Dir./SSO
4. Zahid Ali Qureshi	MSc	USU	1/1992	AZRI	Agronomy/SO

[1]Transferred to PARC in May 1992 18 months after returning to AZRI.

Table 7.4. Up-date on the status of AZRI LTTs on December 31, 1992.

Name	University	Degree	Subject	Start year	End year	Extension granted
Khanwar Nasir	Ohio State	PhD	Veterinary science	1988	1992	Yes
Arshad Ali	Arizona State	PhD	Plant nutrition	1990	1993	Yes
Asghar Ali	Colorado State	PhD	Plant breeding	1990	1994	Applied
Khalid Mahmood	Oklahoma State	PhD	Ag. economics	1990	1994	?
Atiq-ur-Rehman	West. Australia	PhD	Ruminant nutrition	1991	1995	?
Ghulam Akbar	Utah State	PhD	Range science	1991	1995	?
Ahmad Samiullah	Iowa State	MSc	Soil science	1993	1994	-

It is significant that Mr Khanwar Nasir completed his PhD at Ohio State in June 1992 and has proceeded to take another course in the USA (Table 7.4).

Mr Ahmad Samiullah, SO in the Agronomy Section, secured placement on an MS program in Soil Science at Iowa State University. He left Pakistan in early January 1993 and has to complete his program by August 1994 when MART ends.

Short-term training. From December 26 to 30, Mr Anwar Khan (Head, Germplasm Section) and Mr Tariq Javid (Librarian) attended a course at the NARC Training Center on "Searching of International Databases on CD-ROM".

Workshops/Meetings

An international workshop on small ruminants was held in Quetta in December. It was organized by ICARDA headquarters and sponsored by GTZ. Participants came from Afghanistan, Morocco, Iraq, Pakistan and Turkey, as well as from ICARDA headquarters and the Ankara office. The Pakistani participants came from the provincial Livestock Department, from NARC and PARC, and from the FAO/UNDP Sheep and Wool Project at NARC.

Dr Sarwat N. Mirza (SO, Head Range Section) attended a sub-regional international meeting of the Dryland Pasture and Forage Legume Network, organized by the ICARDA Pasture, Forage and Livestock Program and held in Ankara, October 20-22, 1992. He presented an overview paper of the range research at AZRI. Two other staff from Pakistan and Iran also attended this workshop. This is evidence of the catalytic role ICARDA is playing to involve scientists from other countries of its highland region and other regions of Pakistan, as well as those from AZRI.

Seminars

The AZRI occasional seminar series, open to AZRI and staff of provincial departments, continued throughout the year. It included the following speakers and subject areas:

1. Zahid Ali Qureshi. Water harvesting from compacted soil surfaces to improve the productivity of rainfed agriculture. 25 February.

2. Rafique, Shahid. Fertility of range-based ewes as influenced by improved nutrition in highland Balochistan (Kalat). 17 March.

3. Johnson, Duane. Haploid Breeding in Cereals. 26 May. (Dr Johnson is Assistant Professor in the Department of Agronomy, Colorado State University, Fort Collins and supervisor of Asghar Ali who is doing research for a PhD on lentil breeding.)

4. Johnson, Duane. Germplasm utilization in Chenopodium. Department of Agronomy, Colorado State University, Fort Collins. 28 May.

5. Khan, Mohammad Anwar. Use of male sterility in barley improvement. 2 July.

6. Shah, Imran Ali. Marketing of goat and sheep skins in highland Balochistan. 6 July.

7. Ahmad, Sarfraz. Breeding methods for self-pollinated crops. 13 August.

8. Rafique, Shahid. Frequency of cotton seed meal supplementation in beef heifers grazing blue grama ranges in New Mexico. 19 August.

9. Call, Christopher A. Vegetation manipulation on range lands. 7 September. (Dr Call is Assistant Professor in the Department of Range Science, Utah State University, Logan and supervisor of Ghulam Akbar who is doing research for a PhD.)

10. Ahmad, Nisar Malik. Weeds and their control-application of herbicides in wheat. 8 September.

11. Thomas, David. Comparison of US sheep breeds. 22 November. (Dr. David Thomas is Professor of Animal Breeding and Genetics, Department of Animal and Dairy Science, University of Wisconsin, Madison). He was visiting AZRI to see the BOSTID project on small ruminants supervised by Dr Shahid Rafique.

12. Samiullah, Ahmad. Role of meteorology in agricultural research. 31 December.

Annex 1. Journal papers, and MART/AZR Research Reports and Other Reports

Papers in refereed Pakistani and International Journals

Afzal, M., M.I. Sultani and M. Asghar. 1992. Growth of fourwing saltbush on the rangelands of upland Balochistan. Pakistan Journal of Agricultural Research 13: 180-183.

Keatinge, J.D.H., A. Rodríguez, G. Farid Sabir, A. Afzal and N.A. Shah. 1992. Camels in the farming systems of the arid highlands of western Pakistan: is management research a worthwhile investment. Journal of Arid Environments. 23: 293-300.

Asghar, A., S. Ahmed, B.R. Khan and J.D.H. Keatinge. 1993. Selection of vetch genotypes under rainfed conditions in highland Balochistan. Pakistan Journal of Agricultural Research. In press.

Usman, M. 1992. Consumption linkages of mechanical wheat production in Pakistan. The Pakistan Development Review. 31: 929-938.

MART/AZR Project Research Reports

Khan, B.R., E.F. Thomson and A. Rodríguez. 1992. AZRI research plans for 1992/93. MART/AZR Project Research Report No. 77, ICARDA Quetta.

Rodríguez, A. 1992. Social and Economic Considerations of Sheep and Goat Production and Marketing in Balochistan. MART/AZR Project Research Report No. 74. ICARDA, Quetta.

Rodríguez, A. I. Ali Shah, M. Afzal and N.A. Shah. 1992. Marketing of Goat and Sheep Skin in Highland Balochistan. MART/AZR Project Research Report No. 76. ICARDA Quetta.

Thomson, E.F. and S. Rafique, S. 1992. Small ruminant research in highland Balochistan. MART/AZR Project Research Report No. 75, ICARDA Quetta.

Other Reports (including conferences/workshops)

AZRI (Arid Zone Research Institute)/ICARDA (International Center for Agricultural Research in the Dry Areas). 1992. The MART/AZR Project, Pakistan: Annual Report 1991. AZRI/ICARDA Quetta.

Mirza, S.N. 1992. Priorities for Range Research in highland Balochistan. Paper presented in the Regional Meeting of ICARDA Pasture, Forage and Livestock held at Ankara, Turkey from 19-23 October, 1992.

Rodríguez, A. 1992. Social and Economic Considerations of Sheep and Goat Production and Marketing in Balochistan. In: USAID sponsored Workshop on Small Ruminant Production: Systems for Sustainability. New Delhi, 26/27 February. (Also published as MART/AZR Project Research Report No. 74.)

Rodríguez, A. and Imran Ali Shah. 1992. The Socio-Economics of Skin Market: A

Neglected Issue in the Leather Industry. Pakistan Leader Trade Journal, July-Sept. 51-56.

Rodríguez, A. I. Ali Shah, M. Afzal and N.A. Shah. 1992. Marketing of Goat and Sheep Skin in Highland Balochistan. MART/AZR Project Research Report No. 76. ICARDA Quetta.

Thomson, E.F. and S. Rafique, S. 1992. Small ruminant research in highland Balochistan. In: USAID sponsored Workshop on Small Ruminant Production: Systems for Sustainability. New Delhi, 26/27 February. (Also published as MART/AZR Project Research Report No. 75.)

Usman, M. 1992. Zhob Area Development Study. Pakistan Agricultural Research Council, P.O. Box. No. 1031, G-5/1, Islamabad.

Annex 2. AZRI Headquarters Scientific Staff, and ICARDA MART/AZR Project Staff on December 31, 1992.

(Staff with names preceded by an "*" joined during 1992)
(Staff with names preceded by a "+" left during 1992)

Director	Bakht Roidar Khan (PSO[1], PhD)
Agronomy/water-harvesting Section	K.N. Babar (PSO, Deputy Director)
	+Nisar A. Malik (SSO[2]), left in December
	Muhammad Islam (SO[3])
	M. Arshad Ali (SO, LTT[4])
	+Mohammad Aslam (SO), left in May
	Zahid Ali Qureshi (SO, LTT)
	Ahmad Samiullah (SO)
Germplasm Section	M. Anwar Khan (SO)
	Safraz Ahmed (SO)
	Irshad Begum (SO)
	Asghar Ali (SO, LTT)
	S.A. Jaleel (ASO[5])
Range Section	*Sarwat N. Mirza (SO, PhD), joined in May
	+Abdul Wahid Jasra (SSO, PhD), left in May
	Javed Afzal (SO, ad-hoc appointee)
	Abid Hussan (SO, ad-hoc appointee)
Livestock Section	Shahid Rafique (SSO, PhD)
	+Muhammad Munir (SO), left in May
	*Inam ul-Haque (SO), joined in March
	*Ejaaz Rasool (SO, on contract), joined May
	Atiq-ur-Rehman (SO, LTT)
	K. Nasir Mahmood (SO, LTT)
	*Riaz Hussain (SO, BOSTID funded) joined Nov
Economics Section	Usman Mustafa (SO, PhD)
	Khalid Mahmood (SO, LTT)
	Muhammed Afzal (ASO)
	Mohammad Jamil (SO, ad-hoc appointee)
	Imran Ali (SO, on contract)
	Nisar Ali Shah (ASO, BOSTID funded)
Extension Section	M. Bilal Ahmad Chowdry (SO)
Agricultural Engineering	*M. Adel Akbar (AAE), joined in December

[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 Project Staff

Euan F. Thomson	Team Leader; Livestock/Range Advisor
Alister Y. Allan	Agronomy/Germplasm Advisor (left March 31, 1992)
Abelardo R. Rodriguez	Agricultural Economics Advisor (left July 15 1992)
Pesi R. Amaria	Office Manager/Financial Administrator (Consultant)
M. Zafar Jalil	Assistant Financial Administrator
Kathy Javed Gill	Secretary
Aslam James	Driver (left March 31, 1992)
Nazir Patrick	Driver (left July 31, 1992)
Sharafat Barkat	Driver
Eric Masih	Driver
Yousaf John	Driver