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The MART/AZR Project
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Annual Report

Arid Zone Research Institute
Quetta, Pakistan

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

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HIGH ELEVATION RESEARCH IN PAKISTAN
THE MART/AZR PROJECT

ANNUAL REPORT 1991

Arid Zone Research Institute (AZRI)
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and

International Center for Agricultural Research in the Dry Areas
(ICARDA), PO Box 5466, Aleppo, Syria

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Acknowledgement

Phase II of the MART/AZR project has now completed two 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 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 and currently has three resident advisors posted at AZRI.

During 1991 intensive negotiations between PARC, USAID and ICARDA generated a mechanism whereby USAID would continue funding MART/AZR through to August 1994 when the MART project ends. This extension takes MART/AZR well beyond the original completion date of September 31, 1991. It was made so that AZRI would have continued support from ICARDA until most of its scientific staff have returned from the USA where they are on long-term training. Furthermore, it would also provide more time to help AZRI graduate from being a donor supported institute to becoming a fully fledged institute within the PARC system with strong linkages to other national institutes in the region and ICARDA.

The extension of MART/AZR was granted by USAID, despite the scaling down of their activities in Pakistan following the implementation of the Pressler Amendment in October 1990. This resulted in the dramatic cutting of support to most USAID projects, including a reduction of funding to MART from $8 million to $3 million, all of which is being used for the BOSTID component of MART Phase II. The current phase of the project is thus being financed from savings made during Phase I. The extension is evidence that USAID has considerable faith in the continued evolution of AZRI towards the project's goals, following the solid start made during Phase I.

Particular thanks are due to the new Chairman of PARC, Dr Zafar Altaf, and to the former PARC Member Natural Resources, Mr Muhammad Rafiq, who both provided continuous support and encouragement to AZRI during 1991.

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

During 1991, ICARDA staff in the Quetta office have 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 totally in-charge of the office during the Gulf Crisis when all three ICARDA advisors were absent for about six weeks.

Thanks are also extended to the scientific staff of AZRI who are responsible for most of the research shown in this Annual Report.

February 1992

Euan F. Thomson
ICARDA Team Leader

Bakht Roidar Khan
Director, AZRI

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

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List of Common Abbreviations

AZRI	Arid Zone Research Institute
BOSTID	Board of Science and Technology for International Development, National Academy of Sciences, Washington
CBWH	Catchment-basin water-harvesting
CV	Coefficient of variation (%) (standard deviation as % of mean)
DM	Dry matter
FAO	Food and Agriculture Organization of the United Nations
FYM	Farmyard manure
GOB	Government of Balochistan
GOP	Government of Pakistan
ICARDA	International Center for Agricultural Research in the Dry Areas
MART	Management of Agricultural Research and Technology
MART/AZR	Management of Agricultural Research and Technology - Arid Zone Research (component)
PARC	Pakistani Agricultural Research Council
SD	Standard deviation
SED	Standard error of difference
TDM	Total dry matter
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 185 km west of Loralai in Loralai Province. The station uses a block of land belonging to the Forestry Department. It has 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.

Zarchi Range/Livestock Station

This station is situated about 25 km west of Kalat, in Kalat Province. AZRI has a block of land on loan from the late Sardar Raisani. The station has 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 Balochi sheep and 10 goats are kept at the station which is 3-4 hours drive from Quetta.

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 water harvesting and FWSB, and for seed multiplication.

Karkasa National Park

Karkasa National Park is a valley controlled by the Balochistan Forestry Department situated close to AZRI Station. It has been protected from grazing for about seven years and is used for collaborative studies on FWSB.

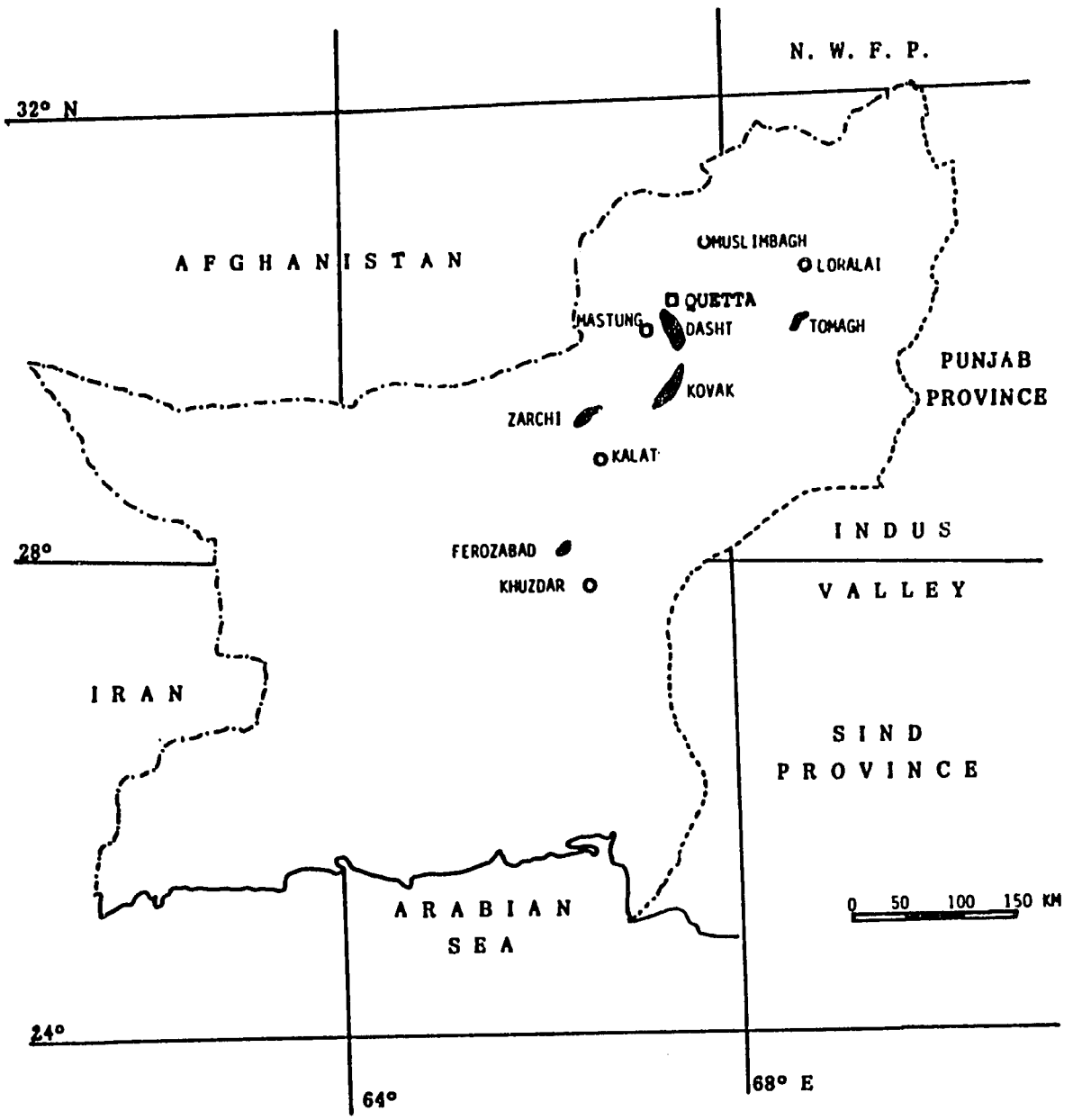
Catchment Basin Water-harvesting Trial Sites

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), Kan Mehtarzai, Kalat, Kili Bokhara (Loralai).

Map showing AZRI Research Sites in Balochistan Province, Pakistan



Chapter 1

Project Goals, Purpose, Activities and Issues

This chapter aims to provide the framework to understand and assess the project activities which are outlined in the following chapters. The goals and purpose 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 range of issues, from the BOSTID grant awards to 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 AZRI requested in June 1991 (see Chapter 8).

Project Activities

The research activities at AZRI are conducted by five different sections.

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

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

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

feed and key animal production parameters are being determined.

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

The activities of the **AZRI Agronomy and Germplasm Sections** include:

a. Examination of water harvesting techniques and distribution within fields. This includes the study of contour bund design, spillways in bands, field levelling with locally available technology, surface sealing technologies, etc.

b. Possibilities of using spillover water not needed in the cropped area of water catchment studies for establishing range forage/shrub reserves. This will include the testing of dual-purpose forage and fuel wood species.

c. Studies on integrated annual forage/forage shrub production practices to maximize forage production from scarce rainfall.

d. The Range and Livestock Sections are being helped to examine ways in which micro-catchment runoff systems promote better and more sustained productivity of range vegetation.

e. Studies on the introduction of improved germplasm of forage and dual-purpose crop species (barley, vetch, lentil, wheat, etc.) with improved water catchment systems.

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

The activities of the **AZRI Agricultural Economics Section** include the following:

a. Profitability and compatibility of AZRI-generated technologies with current agricultural systems. This requires assessment of both individual technologies as well as enterprise option studies in order to maximize farm 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 a survey of current meat, wool and skin marketing practices and recommendations will be made to improve the returns to producers from the sale of better quality livestock products.

c. Determining whether alternative agronomic strategies in combination with 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. Developing a model to measure the impact of AZRI technologies on farm productivity and to help prioritize research activities according to the potential benefit to farm productivity and income stability.

e. Assisting other AZRI Sections to evaluate farmers' perceptions of alternative technologies.

BOSTID Grants

In early August 1991 AZRI was awarded two BOSTID grants which are a component of the MART project. 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 can be up to $100,000 and are spread over a three year period, 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 80 proposals were submitted for the first tranche of awards.

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?". Both awards are for about $67,000 over a three year period starting in January, 1992.

Changing the Emphasis of AZRI Research

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 recognise this need.

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. During 1991 such research was severely constrained by a shortage of scientific staff. This is largely because three staff are away on long-term training; one will return in 1993 and the other two in 1994 and 1995. Thus, it was only possible to conduct modest studies on sheep nutrition and management at Tomagh and Zarchi. The efforts of the Range Section were devoted to starting a new research program on fourwing saltbush which will begin to generate results in 1992. The activities and results from 1991 are reported in Chapters 3 and 4.

Socio-economic studies

Research on problems of agricultural production, marketing and export 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 and skins (Chapter 5). 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 also started. The latter study will provide key information for the planning of production and marketing.

The Section has addressed the need to link research at AZRI with the agri-business sector in Balochistan. One activity was a consultancy to assess the scope of this sector in Balochistan (see MART/AZR Report No. 72, 1991). The sector is fairly well developed for serving irrigated fruit production but very poorly developed to serve rainfed agriculture and pastoral based small ruminant systems. Interest in developing a large scale commercial seed industry for rainfed crops is unlikely to arise since the area of rainfed wheat, the principal crop, is only about 200,000 ha. However, the seed could be produced and certified on semi-privatized government farms. An informal survey of the farm machinery "industry" in Quetta showed that local machinery companies are capable of supplying spares brought from outside the province, but there is no capacity for local manufacture of even a relatively simple seed-drill.

It is therefore premature to expect close linkages between AZRI and agri-business until a demand has been created for some of the technologies that are being tested, such as fourwing saltbush, the camel-drawn seed-drill, and better crop varieties. The recommendations and conclusions of the agri-business consultant are shown in Chapter 8.

These findings re-emphasize the poverty of the farming and pastoral community in highland Balochistan. The producers are mostly subsistence oriented and either have no savings to invest in their farm or flock, or do not want to risk investing in technologies that, to them at least, may only have a marginal benefit. AZRI will always face this problem when attempting to introduce new technologies. This is the main reason why farmers should be involved from the moment a new technology is first identified and research initiated, whether on a research station or in on-farm trials.

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 6). The technology has now been investigated for five years and is being more critically reviewed than ever before. The timing is appropriate since the BOSTID supported project on water-harvesting starts in 1992.

It is clear that the method of water-harvesting currently being used increases yields of crops compared to the control treatment, provided the yields are expressed per hectare of cropped area. However, as will be seen in Chapter 5, this is a questionable approach given that not using the water-

catchment area for crop production has an opportunity cost. If this argument is accepted then crop yields should be based on the sum of the catchment and cropped areas. The argument centers on whether or not land is limiting in highland Balochistan. It is generally assumed that it is not, given that much of the land appears to be left fallow each year. However, there is evidence from some field observation in areas where AZRI has its water-harvesting studies that land may indeed be limiting. Further surveys will be needed to resolve this issue.

Doubts still remain whether or not farmers are likely to adopt the water-harvesting technology in its present form, irrespective of the arguments indicated in the previous paragraph. For this reason two new initiatives will be taken in 1992. One is to study more systematically farmers' perceptions of water-harvesting, and the other is to investigate alternative methods. A trial using a different lay-out has already been initiated at Mastung following the visit in December of Dr Oweis, the recently recruited ICARDA water-harvesting specialist based at headquarters in Syria. Many of these activities will be components of the AZRI contribution to the Dryland Resource Management Project being organized by Dr Bailey who is also based at ICARDA's headquarters.

Germplasm Improvement

There is some evidence of progress in the germplasm improvement research. In general, new materials are being identified that carry special attributes but are not necessarily higher yielding than the local landraces. Examples are resistance to yellow rust in wheat, earlier maturity in spring-planted barley and large-seededness in lentils. The main results are shown in Chapter 7 of this report.

Some wheat genotypes have been identified with resistance to yellow rust but it will not be clear how robust this resistance is until more thorough testing is conducted. Such testing is already being made at the NARC Cereal Diseases Research Institute in Karachi and once resistance has been confirmed seed multiplication can begin. It will also be necessary to acquire from ICARDA headquarters more lines with resistance to yellow rust.

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 1991 with the return of two more AZRI scientists from long-term training in the USA. In addition, a previous AZRI staff member took over as Deputy Director and Head of the Agronomy Section in place of the previous incumbent who was appointed PARC Regional Coordinator in Balochistan. The arrival of an agricultural economist in November to head the Economics Section is the first transfer made by PARC to AZRI during Phase II.

These recruitments markedly change the relative strengths of the various AZRI Sections, as can be seen in Figure 1.2, which compares these strengths at the end of 1990 and 1991, with an estimate for the end of 1992, 1993 and 1994. Ad-hoc appointees have been excluded from the analysis. It is clear that the Agronomy and Germplasm Sections are now the numerically strongest, whereas the Range, Livestock, Extension and, to a lesser extent the Agricultural Economics, Sections will continue to be weak. However, with

the imminent lifting of the Government ban on recruitment, it is hoped that additional staff will join AZRI in 1992. Attention will need to be given to increasing the operating budget of AZRI so that when the MART project ends in 1994 the training and research efforts of the last six years can be sustained.

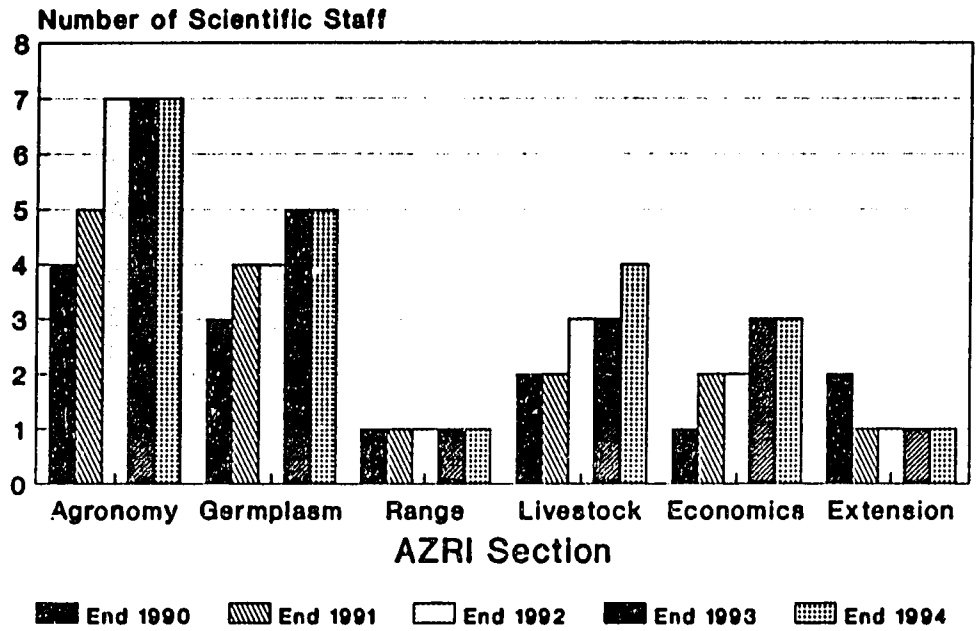


Figure 1.2. AZRI regular scientific staff by Section at the end of 1990 and 1991, and projected to the end of 1992, 1993 and 1994 when all long-term trainees will have returned. Ad-hoc appointees, and short-term consultants funded from MART are excluded.

The Future

The most important domestic issues still remaining are the strengthening of the scientific staffing at AZRI, development of collaborative projects between AZRI and NARC scientists, and an increase in the AZRI operating budget. The staffing situation is improving, as mentioned in the previous section.

Initiation of collaborative projects between AZRI and NARC is now a high priority. It is a rational goal since AZRI has many research issues that need to be addressed. However, it is unjustifiable to have resident scientific expertise when NARC has comparative advantages in this respect. Areas where such collaboration could be initiated include: laboratory testing of wheat germplasm for resistance to yellow rust, studies on the mineral metabolism of range-based sheep, and further development of the camel-drawn seed-drill.

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.

Efforts will also be increased in 1992 to launch a quarterly AZRI Research Brief. Each issue will contain one or two 1000 word reports about emerging AZRI technologies and it will be sent to a wide audience both in and outside Pakistan. It will be produced by AZRI staff with some editorial help from the ICARDA advisors. The first issue of the quarterly newsletter called AZRI NEWS, was printed and circulated in November 1991.

In March 1992 Dr Alister Allan will leave the project. He has been the resident ICARDA scientist responsible for advising AZRI on agronomic, water-harvesting and germplasm research. ICARDA has agreed to replace him with a scientist who will be responsible for assessing farmers' perceptions of technologies studied at AZRI during the last six years. These include fourwing saltbush, water-harvesting, the camel-drawn seed-drill and improved varieties of food and feed crops.

There are now two cropping seasons until the end of the MART project in August 1994. During this time special attention will be to given to studying the 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. A major effort will also be made to ensure that AZRI has an efficient and effective system of research station management in place as the long-term trainees return.

ICARDA Advisor: Euan F. Thomson

Chapter 2

Weather Conditions in 1990/91

Introduction

Balochistan has an arid to semi-arid environment in which the effects of agro-climatic elements such as temperature and rainfall on agricultural production are vitally important. Summers are very hot, winters are cold and harsh, and the rainfall is low and extremely variable. Most of Balochistan is on the fringe of the monsoon areas and therefore does not receive reliable summer rainfall, whereas the winter precipitation is relatively more reliable. Consequently, AZRI has focused much of its attention on rainfed winter crops in highland Balochistan.

Rainfall

The winter precipitation in highland Balochistan is largely associated with the passage of eastward travelling, low pressure disturbances which originate in the Mediterranean. These disturbances bring widespread winter precipitation in the form of rainfall or snow between November and March. Summer rains in these areas are due to monsoonal depressions which develop in the Bay of Bengal, but which usually discharge all their rain before reaching the NE fringes of highland Balochistan (Kidd *et al.*, 1988).

The weather summary tables presented later show that in 1990/91 the areas where the trials were located received most of their rainfall in the winter months, between December and March. The rainfall in 1990/91 in the Quetta valley was about 60% above the mean, while at Mastung and Loralai it was well below average; this illustrates the high temporal and spatial variability of the annual rainfall.

Temperature Regime

Temperature is the second most important agroclimatic variable after rainfall. Within a locality, there is a general relationship between temperature and altitude, with the mean temperature decreasing by 0.5 to 1.0°C for every 100 meter increase in elevation (Kidd *et al.*, 1988). The number of frost days with temperatures below freezing varies from location to location. These freezing events are very important to agriculture in every locality. The first frosts around Quetta are expected in early November whereas in Loralai they start later. These frosts can be particularly important to the germination of winter crops as well as to vegetable and fruit production. At the end of the winter season late frosts, when fruit trees are in blossom, have particularly damaging effects on fruit production, and can also cause severe and irretrievable damage to other crops. Under such harsh conditions, exploratory agronomic research needs to concentrate on cereal and legume species and cultivars which have a considerable degree of cold tolerance so that they can survive superficial "burning off" of the top foliage; they should also possess good regrowth potential if they are damaged by frost.

Automatic Weather Stations

Automatic weather stations have been operating at the experimental sites for several years and record 17 different weather parameters. All the sensors are scanned every minute, thus averages, totals, minima and maxima refer to a data set of 1440 values per day. The most important meteorological data collected from the different trial sites during the 1990/91 season are summarised in Tables 2.1. to 2.6.

Table 2.1. Meteorological data at AZRI Quetta (altitude 1680 m) in 1990/91. (See footnote for explanation of meteorological parameters).

Month /Year	Rain (mm)	Air temperatures, °C Min.	Max.	Mean	DBZ	EO (mm)	SRad (MJ)	Wind (m/s)	RH (%)
7/90	-	21	36	29	-	212	29	2	22
8/90	-	21	36	28	-	189	26	2	31
9/90	-	16	32	24	-	159	23	2	19
10/90	-	9	24	17	-	122	20	2	16
11/90	0.6	5	20	12	-	78	16	2	19
12/90	41.3	1	12	7	10	49	11	2	47
1/91	85.8	-1	8	4	18	44	11	2	63
2/91	83.8	1	11	6	10	62	15	3	47
3/91	122.6	5	16	10	2	51	18	2	49
4/91	52.6	10	22	16	-	160	24	2	32
5/91	4.0	16	29	23	-	189	24	2	21
6/91	-	19	35	27	-	160	28	2	12
Total	390.7	-	-	-	40	-	-	-	-
Means	-	10	23	17	-	123	23	3	32

Notes:
Air temperatures - minimum, maximum and mean monthly averages (°C); DBZ = days below zero °C; EO = approximate evapo-transpiration (mm/day); SRad = total solar radiation (MJ/m^2/day); Wind = average wind speed (meter/sec); RH = relative humidity (%)

Table 2.2. Meteorological data at ARI, Sariab, Quetta, (altitude 1670 m) in 1990/91.

Month /Year	Rain (mm)	Air temperatures, °C Min.	Max.	Mean	DBZ	EO (mm)	SRad (MJ)	Wind (m/s)	RH (%)
7/90	-	17	36	27	-	199	27	2	24
8/90	0.5	19	35	27	-	187	23	2	41
9/90	0.3	11	31	21	-	138	21	2	26
10/90	-	4	24	14	7	95	18	2	19
11/90	-	1	19	10	11	56	14	2	33
12/90	22.4	-1	11	5	13	46	11	2	49
1/91	80.0	-1	8	4	19	40	11	2	67
2/91	78.2	-1	11	5	14	62	15	3	57
3/91	103.2	4	16	10	4	102	18	3	56
4/91	39.6	7	22	15	-	135	23	2	40
5/91	19.3	13	28	21	-	169	24	2	37
6/91	-	15	33	24	-	189	28	2	21
Total	343.5	-	-	-	68	-	-	-	-
Means	-	8	23	15	-	118	19	2	34

Table 2.3. Meteorological data at Mastung (altitude 1650 m) in 1990/91.

Month /Year	Rain (mm)	Air temperatures, °C Min.	Max.	Mean	DBZ	EO (mm)	SRad (MJ)	Wind (m/s)	RH (%)
7/90	0.8	17	38	28	-	201	28	2	24
8/90	1.3	16	38	27	-	196	25	3	39
9/90	-	11	34	22	-	145	23	2	21
10/90	0.8	3	26	14	6	103	19	2	18
11/90	2.5	-1	20	9	17	54	15	1	27
12/90	25.6	0	8	4	17	29	11	2	62
1/91	84.3	-1	10	5	21	24	12	1	83
2/91	40.1	-1	13	6	17	45	15	2	67
3/91	56.3	4	18	11	6	24	17	2	68
4/91	29.9	7	24	15	-	54	23	2	49
5/91	0.3	12	31	22	-	164	24	2	28
6/91	-	15	36	26	-	182	29	2	14
Total	239.9	-	-	-	84	-	-	-	-
Means	-	7	24	16	-	102	19	2	42

Table 2.4. Meteorological data at Kolpur (altitude 1760 m) in 1990/91.

Month /Year	Rain (mm)	Air temperatures, °C Min.	Max.	Mean	DBZ	EO (mm)	SRad (MJ)	Wind (m/s)	RH (%)
7/90	-	-	-	-	-	-	-	-	-
8/90	-	-	-	-	-	-	-	-	-
9/90	0.3	10	30	20	-	174	22	3	28
10/90	0.3	2	24	13	-	121	18	3	19
11/90	0.8	-2	18	8	21	81	14	3	22
12/90	28.8	2	11	7	22	53	11	3	50
1/91	60.2	-2	8	3	21	56	13	3	61
2/91	76.1	-2	10	4	20	78	17	4	50
3/91	88.4	4	15	10	4	115	18	4	50
4/91	37.6	7	22	15	-	163	24	4	36
5/91	15.0	12	27	20	-	200	25	4	28
6/91	0.8	14	34	24	-	213	29	3	15
Total	308.8	-	-	-	88	-	-	-	-
Means[1]	-	4	20	12	-	129	19	3	36

[1] Means have less than 12 months data.

In 1990/91, there was very little rain in most areas in the summer (monsoon) season and the first winter rain was not received until after mid-December. There was heavy rain at several sites in February and March, which caused serious waterlogging at the Dasht sites (near Kolpur), but around Quetta the rain stopped rather abruptly in early April. The season's total was lower than average at the Mastung site, but in the Quetta valley it was 60% above normal. Rain in April in areas such as Loralai provided favourable conditions for the spread of yellow rust (*Puccinia striiformis*) which caused moderate losses in zones where the conditions were slightly more humid. However, the losses were not quite as bad as in the previous year's widespread epidemic. The absolute minimum daily air temperatures ranged from -6.9 to -11.6°C and the maximum temperatures ranged from 34 to 41.7°C. There was severe frost in late December, which wiped out plantings made in mid-December. The spring plantings did not experience any late frosts, but very dry winds in April caused desiccation and grain-shrivelling.

Table 2.5. Meteorological data at Tomagh, Loralai (altitude 1800 m) in 1990/91.

Month /Year	Rain (mm)	Air temperatures, °C Min.	Max.	Mean	DBZ	EO (mm)	SRad (MJ)	Wind (m/s)	RH (%)
7/90	11.2	3	33	18	-	273	12	3	33
8/90	45.3	19	30	25	-	212	23	4	55
9/90	17.8	17	29	23	-	209	24	4	38
10/90	2.3	11	24	17	-	169	21	3	19
11/90	6.9	6	19	12	1	100	16	3	22
12/90	29.2	2	12	7	9	70	13	3	34
1/91	22.1	-1	10	5	22	70	14	3	37
2/91	36.4	0	11	5	13	62	15	3	31
3/91	75.6	5	17	11	2	140	18	3	33
4/91	122.1	9	23	16	-	161	22	3	32
5/91	25.4	15	26	21	-	237	25	4	20
6/91	29.3	19	32	26	-	271	29	4	14
Total	423.6	-	-	-	47	-	-	-	-
Means	-	9	22	16	-	165	19	3	31

Table 2.6. Meteorological data at Kili Bokhara, Loralai (altitude 1300 m) in 1990/91.

Month /Year	Rain (mm)	Air temperatures, °C Min.	Max.	Mean	DBZ	EO (mm)	SRad (MJ)	Wind (m/s)	RH (%)
7/90	-	-	-	-	-	-	-	-	-
8/90	12.4	24	36	30	-	149	27	3	38
9/90	1.3	18	36	27	-	174	23	2	28
10/90	-	8	29	19	-	109	20	2	16
11/90	-	6	19	13	1	100	16	3	32
12/90	-	2	12	7	9	70	11	2	36
1/91	11.4	1	12	7	12	70	11	2	36
2/91	26.6	1	16	9	12	92	15	2	36
3/91	45.4	7	14	11	1	118	18	2	39
4/91	116.8	10	26	18	-	151	22	2	36
5/91	25.6	16	32	24	-	212	24	3	23
6/91	0.1	19	37	28	-	230	28	3	13
Total	239.6	-	-	-	35	-	-	-	-
Means[1]	-	10	23	17	-	134	20	2	31

[1]Means have less than 12 months data.

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Chapter 3

Studies on Fourwing Saltbush

Introduction

The geographical area of Balochistan is 34.7 million hectares out of which about 93.4% is rangeland and mountains. The unfavourable topographic, edaphic and climatic conditions limited crop production in this province where nomadic, transhumant and sedentary agro-pastoral systems of small ruminant production are the major activity. The productivity of these small ruminants is far below their potential due to the limited forage on rangelands which provide about 70.0% of feed requirements (Gill *et al.*, 1976). An excessive small ruminant population and traditional grazing practices have resulted in overstocking which has not only affected forage production but has also changed the composition of the vegetation. There has been a continuous decrease in the number of desirable forage species and a corresponding increase in the population of unpalatable plant species.

The rehabilitation of the rangelands of Balochistan requires a consideration of the social, climatic and ecological constraints of the Province. With these constraints in mind, the Range Section of AZRI started working on fourwing saltbush (*Atriplex canescens*) about six years ago. The Forestry Department of Balochistan had already started studies on fourwing saltbush (FWSB) at the Maslakh Range site which was established in 1954 (Rafi, 1965). FWSB grows very well in the continental Mediterranean climate of Balochistan and also provides palatable and nutritious green forage throughout much of the year. Other species of FWSB are being studied in the Indus Valley in a project supported by the Australian Government who awarded a doctoral fellowship to AZRI ruminant nutritionist, Mr Atiq ur-Rehman.

Research on FWSB gathered pace in the mid-1980s under the MART/AZR project and it has now become one of AZRI's most promising so called "new technologies". The Range Section is now devoting all its staff resources to research on FWSB and the Agronomy and Extension Sections also have a project on the intercropping of FWSB with cereals on farmers' fields (see Chapter 6). To meet the high demand for seedlings, the nurseries at AZRI, Tomagh and Zarchi now have a capacity to produce each year 50,000, 10,000 and 10,000 seedlings, respectively.

Plant Interspacing, Forage Production and Utilization

The importance of FWSB for the rehabilitation of Balochistan's rangelands has been clearly demonstrated at AZRI during the last five years. Experiences with FWSB forage reserves established at AZRI, Quetta, Tomagh and Zarchi indicate that if no grazing takes place at an early stage, stands become so dense that sheep and goats have difficulty fully utilizing the forage. For this reason a study was started in 1991 to help determine the optimum plant spacing for sustained forage production and for efficient utilization of forage and rainfall under grazing at different sites. The study is being conducted in collaboration with the Balochistan Forestry Department, Quetta, at AZRI farm and Karkhasa National Park. At each location two blocks of 3000 m^2 each were planted in February and March 1991 with six-month-old FWSB seedlings at 1 x 1 m, 2 x 2 m and 3 x 3 m spacings. This is equivalent to 10,000, 2,500 and 1,111 plants/ha. It is realised that the 1 x 1 spacing is

a very high density and farmers would find it too costly to establish. However, from an experimental point of view it is thought necessary to have this high population so that data from the extremes are generated which will allow optimum plant densities to be determined.

The study will last five years. During the first two years data on survival and growth rate (plant height and crown diameter) will be recorded once every two months. During the last three years forage production and grazing utilization by sheep will be studied. The first measurements taken in June, 1991 are given in Table 3.1. Only three months after planting it was too early to see treatment effects but, nonetheless, a high survival rate was apparent.

Table 3.1. Survival, plant height and crown diameter of FWSB at three plant densities averaged across the four blocks (mean ±SD)

Plant density	Survival (%)	Plant height (cm)	Crown diameter (cm)
1 x 1 m	97 2.4	37 13.9	23 16.0
2 x 2 m	98 1.5	34 2.9	17 1.7
3 x 3 m	95 3.7	39 8.4	23 8.5

Season of Establishment

The most critical growth stage for FWSB is initial seedling establishment. Traditionally, nursery grown seedlings are planted out during early spring. However, without additional watering low seedling survival has often resulted because the young seedlings have to survive through a five to seven month dry period until the start of the next rainy season. The probability of monsoonal rains is too low to risk summer planting and watering of seedlings planted during the hot dry season is very unattractive to farmers because of the labour requirement, and also water may not even be available. The objective of this study is to determine the season of planting which allows maximum seedling establishment with the least amount of additional water.

The study is being conducted at Karkhasa National Park. Seedlings were planted in the four seasons of 1991 in a replicated experiment. The first planting was completed during February, the traditional planting season, and about 96% of the seedlings had established by the end of June, 1991. The other planting seasons were July/August (monsoon planting), October (fall planting) and December (winter planting). The study will last three years and survival rate, crown diameter, plant height and forage production will be recorded.

Effect of Different Soil Media on Germination Rate

It has proved difficult to obtain satisfactory stands of FWSB by direct seeding on an extensive scale (Nord *et al.*, 1970). Many factors such as empty seeds, hard seed coats, and presence of growth inhibitors affect germination. A new study was therefore initiated in the autumn of 1991 which aims to identify economical and efficient procedures which maximize germination rate.

Seven different types of soil media are being used:

- ordinary light textured soil,
- plain sand mixed with sieved manure (1:1 ratio),
- plain sand, light textured soil and sieved manure (2:1:1 ratio),
- ordinary soil and soil from under FWSB plants (2:1 ratio),
- good garden soil and soil from under FWSB plants (2:1 ratio),
- ordinary soil and Nitrophos fertilizer (NPK ratio 23:23:0) at a rate of 0.4 g/kg soil (equivalent to 100 kg fertilizer/ha), and
- ordinary soil, fine sand and decomposed manure (3:2:1 ratio).

Seeds of FWSB are inside a testa (hard shell) that remains after the fourwings (bracts) are removed by gently rubbing with a brick on a cloth surface. To find how many dewinged testa contain seeds, the testa are immersed in water using the so-called "density separation procedure". Testa which sink usually contain seeds and those that float are hollow. The percent of testa containing seeds is then checked by taking one hundred dewinged testa at random from a batch, cutting them into halves and examining whether they are filled or not. All filled testa are considered to contain viable seeds.

Each treatment is replicated three times in a completely randomized design and each replicate contains 40 black perforated plastic growth bags. One dewinged testa, assumed to contain a viable seed, is placed in each bag. Seeds were sown on September 6 and another batch will be sown in March or April 1992 when the temperature is optimal for germination (13 to 24°C).

Optimum Utilization of Fourwing Saltbush by Sheep and Goats

FWSB plants live for many years and can be grown in different natural habitats. However, they have to be suitably managed to sustain their productivity (Jefferies and Pitman, 1986), either by intense and regular grazing or by periodic cutting. The amount of browse available from 6 and 12 month old regrowths was 30-50% and 70-100% greater, respectively, than the amounts present in unexploited shrubs (Le Houerou, 1986). The amount of accessible browse in ungrazed adult shrubs was only 30-40% of the potential in grazed FWSB. Cutting ungrazed plants at 6-12 month intervals increased the amount of available feed by a factor of 2 to 5 (Le Houerou, 1986). The quality of the feed is also considerably improved, particularly the protein and carotene content of leaves. Efforts are also needed to define effective methods of managing established FWSB stands, particularly by small ruminants (Kernick, 1986), at an intensity which avoids the risk of over-browsing and damage by rodents (Le Houerou, 1986).

The plots for a new experiment on the grazing management of FWSB have been prepared. The objectives of the experiment are to: 1) study the effects of three grazing intensities (50, 70 and 90% utilization levels) on regrowth and forage production of FWSB, and 2) compare the impact of sheep versus goats on regrowth and forage production of FWSB.

Vegetative Propagation of Fourwing Saltbush

Direct seeding of FWSB is known to give poor results while planting nursery grown seedlings is a successful but expensive and difficult method to use for large-scale revegetation schemes. The objective of this new experiment is to test vegetative propagation as a way to establish FWSB.

The experiment is being conducted at AZRI nursery, Quetta. FWSB cuttings with three different lengths (15, 23 and 30 cm) were placed in the soil either vertically or at a 45° angle in mid-February, early March and April, 1991. The experiment was laid out as a replicated 3 x 2 x 3 factorial design. In spite of good and well distributed rains, only nine out of 72 cuttings sprouted and at the end of June, only one was surviving. This indicates that the scope for establishing FWSB through vegetative propagation under arid conditions may be limited. A follow-up study will use growth hormones, such as indol acetic acid, to encourage root initiation and thereby increase the success rate of vegetative propagation. Such a technique, if successful, could be used by a commercial nursery but is unlikely to be appropriate for farm use.

Establishment of an Artificial FWSB Community

A high priority in efforts to revegetate the vast range areas of Balochistan is the establishment of artificial plant communities and the Range Section is studying the feasibility of using FWSB for this purpose. The first phase of the work started in Karkhasa National Park during spring 1991 when about 30,000 seedlings of FWSB were planted on 50-60 ha of range area. A large number of one meter trenches had been dug on the hillside by a previous project and one seedling was planted at each end of these trenches. No water was given at planting. The survival and establishment of the seedlings has been quite encouraging.

Competition of Fourwing Saltbush with Local Flora

Most of the AZRI research on FWSB is being conducted on heavily degraded lands where competition with native plants is low. However, studies need to be conducted on the initial establishment and survival of seedlings among the aggressive local plant species, particularly the invading annual grasses and deep rooted shrubs. For this purpose a 3000 m^2 dense stand of *Artemisia maritima* (sagebrush) was selected in Karkhasa National Park and about 250 FWSB seedlings were planted among the *Artemisia* stand during spring, 1991.

Initial data on establishment of FWSB showed about 95% survival which indicates that this plant species can compete with the local flora. Height and crown diameter will be measured over a three year period to generate growth curves for FWSB in competition with the local flora for soil moisture and nutrients.

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Chapter 4

Research on Ewe Fertility and Lamb Fattening

Introduction

The following chapter is a summary of the research on small ruminant management and nutrition conducted during 1990/91. The activities are modest, being severely constrained by the absence of two staff on long-term training.

Body Condition and Fertility of Sheep

In typical flocks in Balochistan between 60 and 75 lambs are born from every 100 ewes mated (Nagy *et al.* 1989). This low lambing rate is largely because ewes are under-nourished and in poor body condition at mating. Past studies at AZRI on the feeding of supplements before mating, a practice called flushing, improved lambing rates (Rafique *et al.*, 1991; ICARDA/AZRI, 1991). However, some savings in feed costs could be achieved if ewes in good body condition, and therefore fertile, were not flushed. Furthermore, numerous studies show that body condition is a fairly precise predictor of ovulation rate and subsequent lambing rate in prolific ewes. Fertility responses to flushing are quite variable and this makes it difficult to define a level of feeding to ensure conception and a successful pregnancy. In the generally uniparous local breeds of Balochistan body condition during the mating season could determine whether a ewe lambs at all. In the winter 1990/91, studies were conducted at Tomagh and Zarchi which aimed to show that only the thin ewes needed to be fed to increase lambing rate. Body condition score (BCS) is determined by manually assessing the tissue cover over the transverse processes on the first 10 lumbar vertebrae. A value is assigned in half units from 0.5 (at point of death) to 4.0 which is over-fat.

On September 24 and September 30, 1990, BCS was measured on 49 Harnai ewes at Tomagh and 56 Balochi ewes at Zarchi, respectively. Ewes at each site were then divided into three BCS groups: low (0.5-1.5), medium (2.0-2.5) and high (3.0 and above). Ewes in the low and medium BCS groups were then allocated at random to an unsupplemented or a supplemented treatment. There were no ewes in the high BCS group at Tomagh, and insufficient ewes in the high BCS group at Zarchi, to apply the feeding treatment. Supplementary feeding started on October 1, 1990 and consisted of 500 g barley grain with 100 g cottonseed cake daily for each ewe, offered in the afternoon when the animals returned from grazing native range for eight hours. At Tomagh the range is dominated by perennial grasses (*Chrysopogon aucheri* and *Cymbopogon shoenanthus*) and at Zarchi by *Artemisia maritima*.

Breeding started on November 1, 1990 when three breeding rams were introduced to the flocks at each station and rams stayed with ewes until December 31, 1990. There was random mating with multiple sires. Feeding stopped on January 15, 1991. From January 16 to February 28, 1991 a maintenance ration of 400 g barley grain, 200 g cottonseed cake and 1000 g wheat straw was fed daily to all the ewes. All animals were vaccinated against the prevalent viral and bacterial diseases and drenched with Systamex for internal parasitic control. Ewes were weighed every 15 days and records on mortality and lambing date were kept.

The results on fertility and mortality of ewes throughout pregnancy are shown in Table 4.1. Mortality of ewes was low at Tomagh, but at Zarchi some mortality was apparent which decreased as BCS improved. At Tomagh lambing rate of medium BCS ewes was 100%, and 88-94% in the low BCS group. There was no apparent effect of feeding on lambing rate. At Zarchi overall lambing rate was lower than at Tomagh and the lambing rate of ewes in both the supplemented groups responded to feeding. However, the lambing rates in the low and medium groups, averaged over the unsupplemented and supplemented treatments, were similar. Even the lambing rate in the high BCS group failed to reach 100%. Only one pair of twins was born at the two sites.

Table 4.1. Fertility and mortality during pregnancy of ewes at Tomagh and Zarchi in low, medium and high body condition score (BCS) groups, without (-) and with (+) supplementary feeding.

Site	Tomagh					Zarchi				
BCS group	Low		Medium		High	Low		Medium		High
Suppl. feeding	-	+	-	+	-	-	+	-	+	-
Number of ewes	17	17	7	8	0	10	10	14	14	8
No. ewe deaths:										
- pregnant ewes	0	0	0	0	0	0	0	1	0	0
- non-pregnant ewes	1	0	0	0	0	2	1	0	1	0
No. ewes non-pregnant	1	1	0	0	0	1	0	3	1	1
No. ewes lambing	15	16	7	8	0	7	9	10	12	7
No. of twins	0	0	0	0	0	0	1	0	0	0
No. of lambs born	15	16	7	8	0	7	10	10	12	7
Lambing rate (%)	88	94	100	100	0	70	90	71	86	88
Prolificacy[1]	100	100	100	100	0	100	111	100	100	100

[1]Number of lambs born per 100 ewes lambing.

Linear regressions of mean liveweight of each group on time were calculated for the premating period (days -56 to 0) and first trimester of pregnancy (days 0 to 50), using the individual ewe lambing date as the criterion to adjust liveweights to the same stage of pregnancy. The gestation period was assumed to be 150 days. The liveweights on days -56, 0 and 50 of pregnancy were then estimated from regression. The slope of the regressions represented the daily liveweight changes for the premating period (days -56 to 0) and the first trimester of pregnancy.

Fifty-six days before the estimated date of conception (day 0), the ewes in both the low and medium BCS groups at Tomagh showed similar liveweights (Table 4.2). This indicates how ewes can have the same liveweight but a different BCS. During the premating period of 56 days the supplemented low BCS ewes gained more liveweight than the unfed low BCS ewes, as would be expected. However, in the medium BCS group the opposite was the case. During the first trimester of pregnancy supplemented ewes in each group showed gains in liveweight whereas unsupplemented ewes lost liveweight.

Similarly at Zarchi, there were only small difference between the liveweights of the different groups 56 days before mating and ewes receiving supplements gained modest amounts of liveweight (Table 4.3).

Table 4.2. Estimated liveweights 56 days before, at, and 50 days after conception, and estimated daily liveweight changes during the premating period and the first trimester of pregnancy at Tomagh, for low and medium body condition score (BCS) groups of ewes, without (-) and with (+) supplementary feeding.

BCS group	Low BCS		Medium BCS	
Suppl. feeing	-	+	-	+
Liveweight (kg):				
Day -56	27.6	29.5	28.4[1]	27.7
" 0	29.5	33.1	31.4	29.7
" 50	28.7	35.5	31.1	33.2
Daily liveweight changes (g):				
Day -56 to 0	35±14	64±20	73±17[1]	35±30
" 0 to 50	-23±8	40±4	-9±19	64±8

[1]Liveweight and liveweight change on day -42.

Table 4.3. Estimated liveweights 56 days before, at, and 56 days after conception, and estimated daily liveweight changes during the premating period and the first trimester of pregnancy at Zarchi, for low, medium and high body condition score (BCS) groups of ewes, without (-) and with (+) supplementary feeding.

BCS group	Low BCS		Medium BCS		High BCS
Suppl. feeding	-	+	-	+	-
Liveweight (kg):					
Day -56	31.5	29.6	29.6	29.9[1]	32.6
" 0	29.5	32.0	30.5	31.7	32.3
" 50	29.9	36.7	29.7	36.6	32.0
Daily liveweight changes (g):					
Day -56 to 0	-27±11	41±28	17±5	44±31[1]	-5±17
" 0 to 50	2±13	77±31	-23±10	86±32	-16±10

[1]Liveweight and liveweight change on day -42.

The results from this first study on body condition and ewe fertility are equivocal. There was no clear effect of either body condition or feeding on fertility and responses at the two sites were different. A number of explanations for these results are offered.

Feeding only started one month before rams were entered. Thus body condition had too little time to respond and exert its maximum benefit on fertility. Indeed, at Tomagh the benefits of feeding resulted in only 29 g more liveweight gain in the low BCS group, and in the medium BCS group the effect of feeding was negative during the 56 days before mating! Since lambing rate in the latter group was 100% in both fed and control treatments, a BCS of 2.0-2.5 in Harnai ewes may be sufficient to allow conception and a successful pregnancy.

At Zarchi the response to feeding in the low BCS group was 68 g daily liveweight gain, and in the medium BCS group only 27 g. In both groups,

however, the response to feeding was from 70-71% to 86-90% lambing rate, and the lambing rate in the fed groups was similar to unsupplemented high BCS ewes. This suggests that in the Balochi breed it may be necessary to feed ewes in the medium BCS group, a result that needs confirming.

Comparisons of the results at the two sites are difficult because both breed and environmental effects are confounded. However, the similar response to feeding at the two sites indicates that the grazing was providing a similar amount of nutrients. Thus it appears that the optimal BCS to ensure fertility may be different for the two breeds. Future studies will measure body condition once a week during the mating season. This will make it possible to define body condition at mating, and therefore define more precisely the relationship between body condition and fertility.

Despite the lack of a clear result, the experiments showed that savings in supplementary feed could be made by feeding only thin Harnai ewes. However, Balochi ewes in both the low and medium BCS groups may need to be fed. This research will continue as part of the BOSTID project. Vasectomized rams will be used to measure a wider range of ewe reproductive parameters, such as the start and end of the mating season, the frequency of oestrus and return rate.

Fattening Potential of Balochi Lambs

A fattening trial using lambs from the 1989/90 ewe feeding trial was conducted at Zarchi starting in October 1990. Thirty six growing Balochi lambs aged 5-6 months were divided into two groups according to sex and from each group six male and six female lambs were allocated at random to the following three management regimes:

- EM (extensive management): grazing alone.
- SIM (semi-intensive management): grazing and 7 kg concentrate for 12 lambs.
- IM (intensive management): 15 kg concentrate for 12 lambs and no grazing.

Concentrates were offered at one meal in the afternoon after lambs returned from grazing. The concentrate contained lucerne hay, cottonseed cake, wheat bran and wheat straw in the proportions 50:25:15:10, and had a total digestible nutrient content of 55% and a crude protein content of 12% in the dry matter. Lambs were weighed at the start of the trial and then every 15 days for three months. The growth rate of individual lambs was estimated from the linear regression of liveweight with time. A completely randomized design was used to analyze the liveweight and growth rate data.

There were small but significant differences in the mean liveweights of the lambs at the start of the trial (Table 4.4). The EM and SIM lambs lost liveweight during the trial whereas the IM lambs gained liveweight. Lambs on the EM and SIM regimes showed less than 10% mortality whereas the mortality in the IM group was zero.

The loss of liveweight of lambs on grazing alone is a common observation during early winter in Balochistan, especially when the only grazing is an *Artemisia* dominant shrub range. Lambs cannot sustain daily liveweight losses of 26 g during the period of feed deficit of five to six months in winter. For this reason nomads and transhumant flock owners move with their small ruminants and camels to the Indus Valley in winter. It is

unlikely that feeding each day 600 g of concentrate per head is economic and minimum survival feeding to maintain the animals could be achieved using a cheaper diet based on cereal straw and cottonseed cake. Fourwing saltbush, now being intensively studied at AZRI, is also expected to provide maintenance feed for this period at a low cost. Even in the intensive management system lambs only gained 66 g each day which was probably too low to fatten them for marketing before the onset of the coldest part of winter. Studies are still needed to verify whether it is wiser to intensively fatten Balochi lambs aged 5-6 months for slaughter at the end of the year, or to keep them in store condition until the spring and then fatten them for slaughter. Such questions will be investigated as part of the BOSTID project.

Table 4.4. Initial and final liveweights, daily liveweight changes and mortality of Balochi lambs in three management systems at Zarchi from October to December 1990.

	Extensive	Semi-intensive	Intensive	SED
Initial liveweights (kg)	19.5^{ab1}	17.9^{b}	20.2^{a}	0.74
Final liveweights (kg)	15.3^{a}	18.0^{b}	26.4^{c}	1.42
D. liveweight changes[2] (g)	-26.0^{a}	-20.0^{b}	66.0^{c}	-
Mortality (%)	8.3	8.3	0.0	-

[1]Means in same row with different superscripts differ significantly ($P<0.05$).
[2]Estimated from linear regression of liveweight on time.

(This trial was used by M. Munir as partial fulfilment of a Master's degree).

Future Plans

The main activity in 1992 will be the start of the research on sheep productivity supported by the BOSTID project. Effects of supplementary feeding in late pregnancy and early lactation on performance of ewes and lambs will be examined in greater detail than in previous experiments, and studies aiming to measure the growing and fattening performance of Balochi and Harnai lambs will be conducted. A trial postponed from 1991 will be made on the feeding value of different forage crops harvested at the hay and the mature stage. Economic analysis of the previous livestock performance data will be started. Other studies will be conducted provided additional staff are recruited to the Livestock Section.

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Chapter 5

Agricultural Economics Activities

Introduction

During 1991 the Agricultural Economics (AE) Section completed several research activities which were initiated during the first phase of the MART/AZR project. These included the survey on camel utilization in agriculture (Farid Sabir *et al.*, 1991 and Keatinge *et al.*, 1992) and the survey on the economic impact of yellow rust infestation in wheat crops (Ahmad *et al.*, 1991). New activities were initiated, some of which are still of a diagnostic character, to identify bottlenecks in production and marketing, while others are directed towards the demonstration of specific hypotheses relevant to AZRI's research agenda.

A systems framework has been kept in mind in the design of new activities which are self contained. Figure 5.1 is a schematic representation of the AE research agenda. Livestock production and marketing are related to rangeland resources and fodder production. Research on water-harvesting deals with cereal crops as well as forage legumes and perennial shrubs such as fourwing saltbush. Livestock price perceptions by different market agents are needed to assess the potential value of extension services. The seasonal price indices are not only important for suppliers but also for consumers. The domestic and international market for meat, skins and leather products are also included because of their relevance to the provincial economy. The research program shows how information and working tools such as physiological, econometric or simulation models can be used to extend information about the knowledge of AZRI's findings, from producers to consumers, and to emerging entrepreneurs in highland Balochistan. To a considerable extent we are still trying to understand the socio-economic environment, to determine why livestock producers or farmers ignore or neglect certain practices, or why an improvement in productivity may seem very relevant for a producer but may be an unimportant issue in terms of a consumer's demand for agricultural products.

Our efforts to develop stronger relationships with the provincial government and emerging private sector of Balochistan are starting, slowly, to produce results. AZRI is now beginning to be recognized as an institution which has technical know-how for assessing diverse projects for interested parties in the business community, or for government officials who serve the business community. The AE Section is developing into a research group that provides information to and has support from the private sector and government agencies, which cannot themselves devote time to research. In addition, the Section can also allocate some time to extension activities to find out more about other research needs.

This year's activities, presented below, were originally put up as proposals in AZRI/ICARDA (1991) and later expanded in the AZRI Planning Document for 1991/92 (Khan *et al.*, 1991). The ongoing research on water-harvesting reflects the ability of the AE Section to serve other Sections in AZRI; the other research activities in the AE Section describe research projects which are self-contained but useful to other groups.

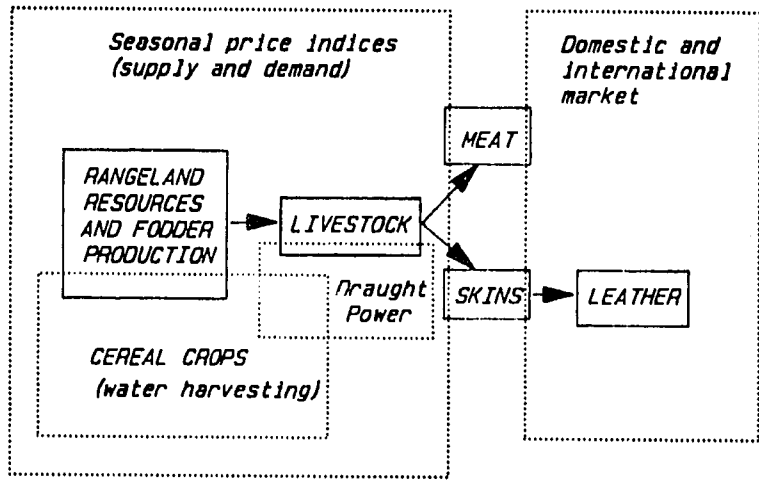

Figure 5.1. Research agenda of the AZRI Agricultural Economics Section

Cereal Crops Grown Under Water-harvesting Techniques in Highland Balochistan

The most important limiting factor for crop production in rainfed areas of Balochistan is the shortage of rainfall and its skewed distribution in both time and space (Kidd *et al.*, 1988). Annual rainfall in highland Balochistan ranges from 175 to 200 mm in the southern districts of Khuzdar and Kalat and from 300 to 350 mm in the northern districts of Loralai and Zhob. Crop production in non-irrigated areas is either totally dependent on rainfall (*kushkaba)* or on runoff water collected from uncultivable land to supplement rainfall (*sailaba*). The minimum water requirement for wheat grain production is about 300 mm and the probability of receiving more than this amount varies from 10 to 50% (Rees *et al.*, 1989a). In contrast, the minimum requirements for barley grain are 225 mm (Rees *et al.*, 1989b); barley has a higher water use efficiency than wheat, and there are higher probabilities of receiving that lesser amount of rainfall. However, barley is not widely grown in highland Balochistan. Most of the farmers grow wheat instead of barley for food security reasons, and because they perceive that there is a poor market for barley and there may be land shortage in certain areas (Nagy *et al.*, 1989, p. 25).

In an attempt to improve the utilization of rainfall, AZRI has been investigating since 1986 the growing of cereals, lentils and forage legumes with different water-harvesting techniques in highland Balochistan. The preparation of small catchment basins on the soils of rainfed valley bottoms represents a low-cost method of generating runoff and increasing crop yields within the cropped areas (Rees *et al.*, 1991). The runoff area is formed by grading it to a slope of 0.5-1.0%, followed by ploughing, cultivating, levelling and smoothing with a wooden beam, and sprinkling with water. The impact of this water and of later rain-drops seals the soil surface into a crust, which allows about half of the subsequent rain to runoff.

The proportions of water catchment area and crop 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 one half of the area is used for

water catchment and one 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 observed runoff efficiencies of 55% for the 1:1 treatment and 43% for the 2:1 treatment are not particularly high for silty clay loam soils. Higher efficiencies could be induced by compaction and/or surface treatment with water repellant chemicals but these would naturally be more costly. A serious problem in these trials is that during wet periods, water-logging can actually occur on the cropped areas, and this can severely damage the crops and reduce yields, if it lasts more than a few days. Therefore, the need for better management of the water on the cropped area to reduce water-logging damage is clearly of high priority (Rees *et al.*, 1991).

The Economics of Water-harvesting

To be economically feasible the crop gains due to the additional soil moisture must be larger than the cost of not planting in the catchment area. The economic feasibility depends on the following inter-related questions:

1) Whether or not the crop area of a water-harvesting treatment yields more than that of the combined crop and catchment areas if they had been used for growing a crop like the control treatment. For example, does the cropped area of the 1:1 treatment yield more than double compared to the control or does the cropped area 2:1 treatment yield more than triple compared to the control?
2) Whether there are reductions in the fixed and variable costs associated with the proportions of the crop and catchment areas,
3) Whether there is any change in the price of outputs (grain and straw) relative to the costs of inputs.

The rationale behind the first question is that there are foregone benefits if there is no planting in the catchment area, and these benefits need to be accounted for. The method used to supply additional water uses land which can be used to grow crops instead of "catching" water. So, the additional soil moisture accumulated in the planted area is not exogenous to the system, whereas for example, the addition of fertilizer would be. Rees *et al.* (1989a, 1991) are not clear about this point, and reduced the variable costs related to smaller cropped areas without accounting for the foregone benefits of the catchment areas. Data on land tenure, as reported in Nagy and G. Farid Sabir (1987), Masood *et al.* (1988) and G. Farid Sabir *et al.* (1991), do not show that *kushkaba* land is unlimited, and the only information available on cropping intensity in highland Balochistan (Rees *et al.*, 1987, p. 9) is not very complete. These sources do not support the conclusion that the opportunity cost of *kushkaba* land is very low or negligible.

The objectives of this study were two fold: i) to compare the economics of water-harvesting techniques and the existing farming practices, and ii) to determine to what extent crop production is increased and production risks are decreased.

Four seasons of wheat trials (1986/87 to 1989/90) and two seasons of barley trials (1988/89 to 1989/90) were used in this study. Wheat yields of grain and straw, and rainfall during the trials, are shown in Table 5.1. Yields for the treatments 1:1 and 2:1 were adjusted for the total area, that is the crop and catchment area (ICARDA, 1989, p. 42), to account for the opportunity cost of not planting in the catchment area. Barley yields of grain and straw, and rainfall during the trials, are shown in Table 5.2. As with wheat, the yields were adjusted for the total area.

Table 5.1. Wheat grain and straw yields (kg/ha), **adjusted to total area**[1], grown with different treatments of water-harvesting in highland Balochistan. Rainfall for each location/trial is also presented.

Season		86/87	87/88			88/89				89/90
Treatment		D/1[2]	D/1	D/2	M/3	D/1	D/2	M/3	K/4	M/1
Control	Grain	562	25	12	8	196	130	166	159	303
	Straw	1531	105	75	108	392	192	324	388	1404
1:1	Grain	608	48	11	5	112	119	122	130	261
	Straw	1283	140	73	70	292	169	345	338	1066
2:1	Grain	397	30	15	8	106	116	126	80	92
	Straw	904	117	90	87	261	209	406	205	903
Rainfall (mm)		282	102	102	96	239	239	167	227	224

[1]Yields in the cropped area were divided by 2 in the 1:1 treatment and by 3 in the 2:1 treatment.
[2]Location/trial: denotes the location (D=Dasht, M=Mastung and K=Kovak) and the trial number.
Source: Rees *et al.* (1991) and AZRI/ICARDA (1991).

Budgets: a budget was developed for each crop, season, location and trial to calculate benefits and costs associated with the treatments (these budgets are available upon request from the AE Section). They reflect the conditions of traditional farming in rainfed areas of highland Balochistan, using camels for the preparation of the land, ploughing, harvesting and threshing. Set-up costs for the water catchment structures were amortized over an estimated ten year durability of the structures; maintenance, tillage, planting and seed costs constitute other fixed costs included in the budget. Variable costs such as harvesting and threshing costs are dependent on how much grain and straw are produced during the current season. The farmgate prices of grain and straw were recorded for each season and site. The grain and straw yields

Table 5.2. Barley grain and straw yields (kg/ha), **adjusted to total area**[1], grown with different treatments of water-harvesting in highland Balochistan. Rainfall for each location/trial is also presented.

Season		1988/89				1989/90
Treatment		D/1[2]	D/2	M/3	K/4	M/1
Control	Grain	119	97	189	168	418
	Straw	239	108	619	358	1278
1:1	Grain	104	68	152	133	317
	Straw	192	123	470	331	1146
2:1	Grain	75	60	162	83	238
	Straw	126	119	539	249	1205
Rainfall (mm)		239	239	167	227	224

[1]Yields in the cropped area were divided by 2 in the 1:1 treatment and by 3 in the 2:1 treatment.
[2]Location/trial denotes the location (D=Dasht, M=Mastung and K=Kovak) and the trial number.
Source: David Rees (personal communication) and AZRI/ICARDA (1991).

were multiplied by their respective farmgate prices to calculate the gross benefits. Total costs were subtracted from the gross benefits to calculate the net benefits.

Wheat: Table 5.3 shows the gross benefits, costs and net benefits of each trial planted with wheat during four seasons. Averages per season (columns A-D) were calculated to assign equal weight to each season. These averages were used to calculate the average and coefficient of variation in columns E and F, respectively. In all locations and trials the 1:1 treatment showed an improvement over the control as far as the net benefits are concerned. Negative net benefits in all locations and trials during the 1987/88 season show the effect of very low rainfall at Dasht and Mastung, which caused very low yields of straw and grain (Table 5.1). However, the less negative net benefits of treatments 1:1 and 2:1 compared with the control show that these water-harvesting practices could reduce the magnitude of losses in seasons with low rainfall (96 to 102 mm). Treatment 2:1 yielded less negative net benefits than the 1:1 treatment during the 1987/88 season and higher net benefits than the 1:1 treatment during the 1988/89 season with the exception of Kolpur 4 (K/4); in the first and last season the cropped area suffered adverse effects due to water-logging.

All treatments in the first and the last season had high yields and net benefits but the first season had highest values. These higher values were not only due to due to 60 mm higher rainfall in the first season but the distribution of rainfall. Better yields can be obtained with rainfall evenly distributed throughout the plant cycle. Kolpur 4 (K/4) in the 1988/89 season shows how average rainfall (227 mm), but with bad distribution resulted in low yields and net benefits. The high net benefits of the first and last season had a strong effect when the results were averaged for all the seasons. The control yielded Rs386/ha, the 1:1 treatment yielded Rs520/ha and the 2:1 treatment yielded Rs397/ha (column E). The 1:1 treatment was above the control and the 2:1 treatment showed inferior performance due to the water-logging effects in the first and last seasons. Furthermore, the coefficient of variation of 1:1 and 2:1 water-harvesting treatments (131 and 137%) was slightly less than that of the control (187%).

A summary of the economic analysis is presented in Table 5.4, comparing the averages and coefficients of variation of the net benefits of treatments for all seasons. The 1:1 treatment had 35% higher net benefits than the control with a 30% reduction in the coefficient of variation. The 2:1 treatment had 18% less net benefits than the control and reduced the variation in net benefits by 27%.

Table 5.4. Summary of net benefits for wheat grown with different treatments of water-harvesting relative to the control (percentages) in highland Balochistan, years 1986-1990 (data from Table 5.3).

Treatment	All seasons	
	Avg[1]	CV[1]
Control	100	100
1:1	135	70
2:1	82	73

[1]Avg=average; CV=coefficient of variation (%).

Table 5.3. Gross benefits, costs and net benefits (Rs/ha) of wheat grown with different treatments of water harvesting for the years 1986-90 in highland Balochistan.

Treatment		Season									Average by season				All seasons	
		1986/87	1987/88			1988/89				1989/90	86/87	87/88	88/89	89/90		
		D/1[1]	D/1	D/2	M/3	D/1	D/2	M/3	K/4	M/1	(A)	(B)	(C)	(D)	Avg[2] (E)	CV[2] (F)
Control	GB[2]	2272	130	81	97	762	446	639	680	1612	2272	103	632	1612	1155	73
	Costs	876	554	547	547	775	730	757	759	894	876	549	755	894	769	18
	NB[2]	1396	-424	-466	-450	-13	-284	-118	-79	718	1396	-447	-124	718	386	187
1:1	GB	2178	204	77	63	496	402	563	574	1298	2178	115	509	1298	1025	77
	Costs	668	363	346	340	482	477	494	496	514	668	350	487	514	505	22
	NB	1510	-159	-269	-277	14	-75	69	78	784	1510	-235	22	784	520	131
2:1	GB	1472	150	98	82	455	431	626	351	790	1472	110	466	790	709	71
	Costs	490	289	281	278	399	402	424	386	393	490	283	403	393	392	19
	NB	982	-139	-183	-196	56	29	202	-35	397	982	-173	63	397	317	137

[1]Location/trial denotes the location (D=Dasht, M=Mastung and K=Kovak) and trial denotes the trial number for one season.
[2]GB=gross benefits; NB=net benefits; Avg=average; CV=coefficient of variation (%).

Barley: Table 5.5 shows the gross benefits, costs and net benefits of each trial planted with barley during two seasons. As with the wheat, averages per season (columns A and B) assign equal weight to each season. The averages per season were used to calculate the average and coefficient of variation in columns C and D, respectively. In four out of five locations and trials the treatment 1:1 showed an improvement over the control with regard to the net benefits, except in Mastung 1 (M/1) in the 1989/90 season. Negative net returns in all treatments at Dasht 1 (D/1) and 2 (D/2) during the 1988/89 season were due to water-logging (Table 5.2). However, the lower negative net benefits of treatments 1:1 compared with the control show the potential of water-harvesting practices to provide additional soil moisture in dry seasons. Treatment 2:1 yielded even less negative net benefits than the 1:1 treatment in Dasht 2 (D/2) and higher net benefits than the 1:1 treatment in Mastung 3 (M/3) in the 1988/89 season; in the other cases, the cropped area suffered negative effects due to water-logging (i.e., more water-logging where the catchment area was larger).

As with wheat, the results were averaged for all the seasons. The control yielded Rs937/ha, the 1:1 treatment yielded Rs999/ha and the 2:1 treatment yielded Rs575/ha. The 1:1 treatment was slightly above the control and the 2:1 treatment showed lower performance due to the water-logging effects in both seasons. However, the coefficient of variation of both 1:1 and 2:1 water-harvesting treatments (110-111%) was less than that of the control (129%). A summary of the economic analysis for barley is presented in Table 5.6. The 1:1 treatment yielded 7% more net benefits than the control and reduced by 15% the variation in net benefits. Treatment 2:1 had 39% less net benefits than the control and 14% less variation.

Results from the wheat and barley trials show that, in spite of higher yields and net benefits of barley compared to wheat, wheat had a better response to the water-harvesting treatments than barley. It was mentioned earlier that water requirements for barley were lower than wheat and that barley had 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. The relative responses of the local varieties of wheat and barley to higher than average levels of rainfall (above 250 mm) are not clear. The water use efficiency coefficients estimated by Rees *et al.* (1989a and 1989b) for wheat and barley were derived from data where only 28% 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 varieties to above-average moisture supplies.

The results of these wheat and barley trials suggest that there are still some technical problems which must be overcome before sustainable increases in crop production and net returns can be ensured; either too little or too much water is harvested and transferred to the cropped area, and only a small reduction in economic risks has been achieved. At best, the treatment 1:1 increased net returns by 35% in wheat and 7% in barley compared to the traditional practice. Correspondingly, economic risks were reduced by 30% in wheat and 15% in barley. ***Are these figures appealing for kushkaba farmers and how many years are needed to determine the effectiveness of a new technology in an extremely variable climate?***

Table 5.5. Gross benefits, costs and net benefits (Rs/ha) of barley grown with different treatments of water harvesting for the years 1986-90 in highland Balochistan.

Treatment		Season					Average by season		All seasons	
		1988/89				1989/90	1988/89	1989/90	Avg[2]	CV[2]
		D/1[1]	D/2	M/3	K/4	M/1	(A)	(B)	(C)	(D)
Control	GB[2]	358	248	688	515	3339	452	3339	1896	76
	Costs	711	696	758	737	1191	726	1191	958	24
	NB[2]	-353	-448	-70	-222	2148	-273	2148	937	129
1:1	GB	304	198	539	432	2977	368	2977	1673	78
	Costs	459	442	493	478	879	468	879	674	31
	NB	-155	-244	46	-46	2098	-100	2098	999	110
2:1	GB	213	180	594	291	1835	320	1835	1077	70
	Costs	369	362	424	378	621	383	621	502	24
	NB	-156	-182	170	-87	1214	-64	1214	575	111

[1]Location/trial describes the location (D=Dasht, M=Mastung and K=Kovak) and trial describes the trial number for one season.
[2]GB=gross benefits; NB=net benefits; Avg=average; CV=coefficient of variation (%).

Table 5.6. Summary of net benefits for barley grown with different treatments of water-harvesting relative to the control (percentages) in highland Balochistan, years 1988-1990 (data from Table 5.5).

Treatment	All seasons	
	Avg[1]	CV[1]
Control	100	100
1:1	107	85
2:1	61	86

[1]Avg=average; CV=coefficient of variation (%).

It is clear that the data available for the analysis does not represent the entire spectrum of weather conditions in highland Balochistan. In situations where rainfall variability so closely governs crop performance, it is necessary to incorporate the probabilities of different rainfall amounts in the economic analysis. Thus, simulation techniques must be used to find probability distributions of net benefits of these cereal crops grown under water-harvesting techniques. The assessment of the adoption potential of this technology will be facilitated by these simulations in conjunction with the quantification of farmers' perceptions of the benefits associated with water-harvesting practices.

Collaborating AZRI Staff: Nisar Ali Shah, Mohammed Afzal

Seasonal Price Indices of Agricultural Commodities/Livestock Products in Quetta

In the description of the AZRI modelling effort (AZRI/ICARDA, 1991, p. 59-66) we mentioned that it was important to incorporate variations in the prices of agricultural commodities for planning production and marketing strategies. To complement the producers' viewpoint, it is relevant to know the price fluctuations of the different commodities, as these fluctuations affect consumers trying to satisfy their food requirements. Table 5.7 shows different groups of agricultural and livestock commodities for which the AE Section has been developing wholesale and retail seasonal price indices. These are the commodities collected by the Agricultural and Livestock Products Marketing and Grading Department, GOP, which is collaborating with AZRI in this study. The seasonal variation is measured by the coefficient of variation, and the months when the maximum and minimum prices occur provide a guideline for production and market planning. This table summarizes the type of information which has been acquired and will be usable in the near future.

The seasonal retail price index for gur (brown sugar), a sweetener very common in the rural areas, is depicted in Figure 5.2. The lowest price paid by consumers occurs in April and the highest price occurs in September, the lowest variation in price occurs in March while the largest variation occurs with the highest price in September. Deviations above and below the price index can be used to forecast prices for different purposes.

Collaborating AZRI Staff: Mohammed Afzal, Nisar Ali Shah

Table 5.7. Wholesale prices (Rs/kg), coefficients of variation (%), and maximum and minimum prices for different agricultural commodities in Quetta (1986-1991).

	Average	CV	Maximum	Minimum
Cereals and carbohydrates				
Wheat flour	2.90	1.4	2.95 (Jan)[1]	2.80 (Mar)
Maida	3.29	1.2	3.34 (Jan & Feb)	3.22 (Mar)
Suji	3.30	5.2	3.44 (Nov)	3.23 (Mar)
Rice Basmati	8.37	1.6	8.57 (Dec)	8.15 (Mar)
Rice Irri	3.16	2.4	3.23 (Nov & Dec)	3.01 (Mar)
Maize	4.04	5.1	4.36 (Sep)	3.52 (Dec)
Sugar	4.48	2.0	9.88 (Sep)	9.26 (Mar)
Gur (brown sugar)	5.53	6.4	6.29 (Sep)	5.03 (Mar)
Potato	2.79	14.3	3.48 (Nov)	2.15 (Apr)
Lentils				
Gram	6.78	1.6	7.02 (Mar)	6.61 (Aug)
Mung	9.13	1.7	9.36 (Jun)	8.83 (Apr)
Mash	10.71	2.2	11.09 (Sep)	10.37 (May)
Masoor	11.24	7.6	12.53 (Jan)	9.82 (May)
Vegetables and spices				
Chillies	18.67	7.8	20.32 (Jul)	15.08 (Nov)
Turmeric	17.20	4.6	18.99 (Aug)	16.33 (May)
Garlic	13.92	10.4	15.18 (Dec)	11.67 (May)
Ginger	36.87	7.6	40.12 (Sep)	32.44 (Jun)
Onion	2.64	16.3	3.28 (Jan)	2.04 (Apr)
Milk and eggs				
Milk (buffalo)	6.45	1.8	6.60 (Jun & Jul)	6.18 (Mar)
Hen eggs (dozen)	10.34	14.8	12.92 (Jan)	7.96 (May)
Meats				
Beef (+ bone)	15.43	2.4	16.08 (Jan & Feb)	14.80 (Aug)
Mutton (+ bone)	41.11	1.9	42.60 (Jul)	39.16 (Mar)
Edible oil				
Rape & Mustard oil	13.48	2.5	14.13 (Feb)	13.10 (Jul)

[1]In parentheses are the months where either the maximum or minimum prices occurred.
Source: Government of Pakistan, Agricultural and Livestock Products Marketing and Grading Department, Quetta.

Expectations of Livestock Prices by Producers and Intermediaries in Highland Balochistan

The elements involved in the pricing of small ruminants are important because they are influenced by ecological, biological and management factors that affect livestock supply, and by cultural and economic factors that affect consumers' demand. Producers, *beoparis* (wholesalers), commission agents and butchers do not necessarily have the same perception of the factors involved in the pricing of livestock. Better knowledge of these factors should help producers and intermediaries improve market efficiency, and benefit both producers and consumers. Quantification of these price perceptions will help to define priorities for the extension services in animal husbandry and marketing.

Consider the following expression:

$$P = f(SP, B, SEX, BC, AGE, LWT, SEA, MDAY)$$

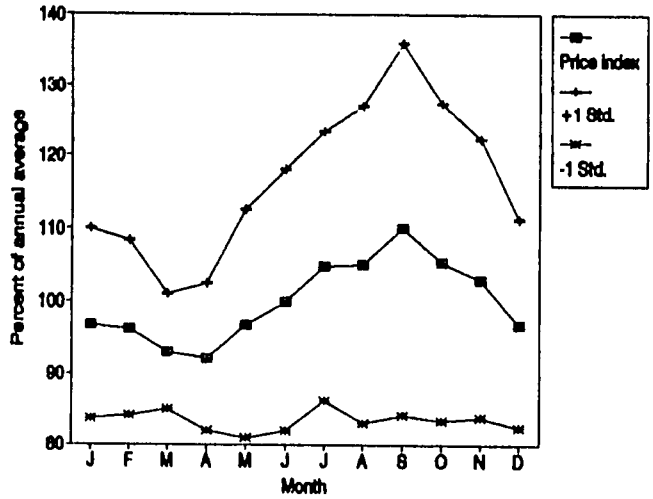

Figure 5.2. Retail price of gur (brown sugar) for different months in Quetta City [100% = Rs6.61/kg (1986-91)].

where P is the expected price of producers or *beoparis* or commission agents or butchers, SP is the small ruminant species, B is the breed, BC is body condition, LWT is liveweight, SEA is seasonality (month) and MDAY is whether or not the data was collected on a meatless day, that is Tuesday and Wednesday when no meat is retailed.

Each month since January 1991, 200 expected prices have been recorded in the Quetta livestock market from two groups: 1) the producers and 2) the intermediaries (either commission agents, *beoparis* or butchers). Half of those expected prices are for sheep and the other half are for goats. For each animal species (sheep or goats), 50 expected prices are from producers and 50 expected prices are from intermediaries. In the absence of any records of livestock transactions in the market, the producers and the intermediaries give the expected price per animal to the AZRI enumerators monitoring group. The expected price given by producers and intermediaries is not for the same animal. Thus, it can be considered as the expected price at the beginning of the bargaining process. In addition to the expected price per animal, the following information is recorded: liveweight measured with a portable scale, the liveweight estimated by the market agent, species, sex, breed, body condition (fatness), calendar year, and whether or not the data were collected on a meatless day. The preliminary results presented below are those from the first ten months of a two-year study.

The average liveweight of goats sold in the Quetta market was 30.3 kg compared to 30.1 kg for sheep. Correspondingly, expected prices for goats were Rs24.8/kg and Rs25.7/kg for sheep. Figure 5.3 depicts the variations in producers' expected prices of sheep, while the intermediaries, "others", have more stable price expectations. The prices expected by the producers are often higher than the prices expected by the intermediaries, which suggests that producers expect more than they get. This was very noticeable during the months of March and June, due to the influences of two important Muslim holidays (Eid-ul-Fitr and Eid-ul-Azha, respectively)[1]. The prices expected by the intermediaries seem to relate to forage availability and

[1]As the two holidays advance, by 10 days per year, these periods when higher prices are expected will advance too.

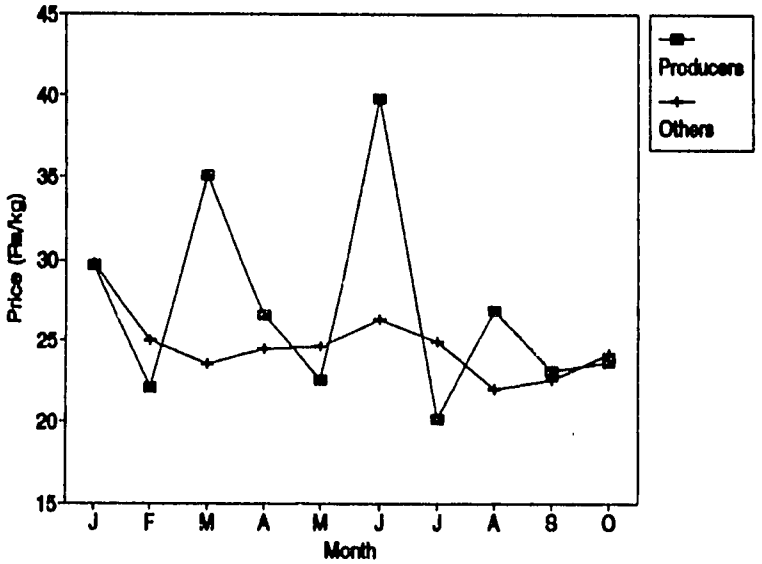

Figure 5.3. Sheep prices expected by producers in Quetta livestock market from January to October, 1991. (Others include commission agents, *beoparis* and butchers).

migratory movements which are seasonal. Expected prices reached almost Rs30/kg in January and dropped to less than Rs24/kg in March when a lot of animals were brought from the lowlands as forage resources in the spring became scarce; prices reached another peak in June, decreasing over the next two months.

There are no agencies in the province that monitor the livestock prices and factors associated with the quality of livestock available in the market. The producers and intermediaries interviewed are potential users of the information generated by this study as well as the provincial and federal agencies responsible for livestock development. Future questions to be answered could be: what is the contribution of these factors to the overall price of livestock, how do they interact and how can they be used as guidelines to extend knowledge to the different market agents in the livestock sub-sector.

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Quetta, the Hub of the Small Ruminant Skin Market in Western Pakistan

Highland Balochistan has approximately 19% of the national population of small ruminants (Mahmood and Rodríguez, 1991); from the annual offtake of 2.1 million head, 90% of the skins or 1.9 million are used in the tannery industry every year. They are shipped to tanneries in the Punjab and Sindh for processing (Mahmood and Walters, 1990)]. The skins of small ruminants produced in highland Balochistan average 0.5 m^2; thus, it is estimated that this part of the province contributes about 0.95 million m^2 to the leather produced in Pakistan. It is difficult to estimate the share of highland Balochistan in Pakistan's exports of leather of about 20.6 million m^2 in 1989/90 (GOP, 1991) because this figure is for both hides and skins. The

estimate is further complicated by the unofficial importation of skins from Iran and Afghanistan; these appear to make up a substantial proportion of the skins traded in Quetta city, the major market for skins in the province. Because of its relevance to the provincial economy, the AE Section initiated a study of the production and marketing of skins. This is also an objective of phase II of the MART/AZR project.

During the summer of 1991, 60 butchers, 35 *beoparis* (wholesalers) and four managers of slaughterhouses from northern (Loralai district), southern (Kalat and Khuzdar districts) and central (Quetta district) areas of highland Balochistan were asked to elaborate on the problems involved in the processing of skins, their distribution along the marketing chain, seasonality of skin production, and costs and services provided. To better understand the quality of skins traded in Quetta, skin warehouses were visited to measure the sizes of skins of small ruminants from Balochistan and the neighboring countries of Iran and Afghanistan. The results summarized below are highlights of this survey.

There are no terminal markets for skins in the province due to the absence of tanneries. The marketing of skins is concentrated in Quetta, the provincial capital. Butchers in this central part of Balochistan operate larger businesses than butchers in the southern and northern areas, and therefore sell more skins to the *beoparis* (Table 5.8). Prices paid by *beoparis* for sheep skins in the winter are 11-25% higher than the prices in summer (Table 5.9). Similarly, prices of goat skins are 17-22% higher in the winter than in the summer. Prices of sheep skins in the winter were 59-82% higher than the prices of goat skins, while the prices of sheep skins in the summer were 47-99% higher than the prices of goat skins.

Table 5.8. Numbers of sheep and goat skins sold daily by individual butchers to *beoparis* in different areas of highland Balochistan (means±standard deviations).

	Quetta	North	South	Significance (t test)		
	(A)	(B)	(C)	(A vs B)	(A vs C)	(B vs C)
Sheep	6.3±3.9	3.8±2.1	2.6±1.5	**[1]	**	--
Goats	8.3±7.8	1.9±1.3	4.4±3.0	**	--	**

[1]**P<0.01.

Table 5.9. Prices of sheep and goats skins (Rs/skin) received by butchers in different areas in highland Balochistan (summer 1991 survey).

	Season	Quetta	North	South
Sheep	Winter[1]	108.2	91.2	92.2
	Summer[2]	90.0	80.7	68.9
	Eid[3]	71.0	65.0	53.5
Goat	Winter[1]	65.3	49.7	58.0
	Summer[2]	55.5	40.7	47.2
	Eid[3]	41.6	32.3	33.3

[1]October-March, [2]April-September, [3]Eid-ul-Azha, which occurs in the Islamic month Hajj, (23 June in 1991).

The northern and southern areas are primary markets while Quetta is an intermediate (redistributive) market; this fact is reflected in the operation costs. Collection, transportation, salting and sorting costs were Rs1546/100 skins in Quetta compared to Rs742-983/100 skins in the north and south.

All butchers and *beoparis* classify the skins by size (Table 5.10). At the aggregate level, there were no differences between the sizes of the sheep and goat skins ($P<0.01$). No differences were found between the sizes from Iran and those from Afghanistan ($P<0.01$). However, significant differences were found between the sizes of skins from Balochistan and those from Iran or Afghanistan. The sizes of all the groups of skins were significantly different except for the small and medium sizes in goat skins of Balochi origin. This is possibly because the differentiation of these sizes is artificial.

A problem faced by the skin purchasers is that the quality of the skins cannot be confirmed until after the wool and hair are removed. Informal interviews with skin purchasers from tanneries in the Punjab who buy in Quetta revealed that the quality of the skins is associated with the origin or the breeds that prevail in those places. Quality depends on thickness, the absence of cuts and scars, and size. In general, skin purchasers consider that the quality of the skins from small ruminants in Balochistan is low with the only exception being the sheep skins from Chaman in the

Table 5.10. Skin sizes (m^2) of different breeds traded in Quetta (summer 1991 survey) (means±standard deviations).

Breed/origin	Size	Sheep	Goat
Balochi	Small	0.44±0.09	0.38±0.05
	Medium	---	0.44±0.05
	Large	0.67±0.09	0.62±0.08
Afghani	Small	0.41±0.08	---
	Medium	0.62±0.07	0.58±0.05
	Large	1.04±0.11	0.88±0.14
Irani	Small	0.37±0.06	---
	Medium	0.54±0.07	---
	Large	0.84±0.07	---

northern areas of the province. Sheep skins from Iran have the highest quality, giving them good export quality, followed by the skins from Afghanistan. Importation of skins has almost no official restrictions on the Pakistani side and no restriction whatsoever from the neighboring countries. Even though there is no official exchange rate between Pakistan and Iran and Afghanistan, the favorable unofficial exchange rate of the Pakistani rupee with respect to the rial (5.34:1 in December 1991) and the Afghani (47:1 in December 1991), contribute to make Quetta the most important trade center for domestic and imported skins in western Pakistan.

An issue often raised by the different market agents involved in the skin trade is the feasibility of establishing a tannery in Balochistan, given the large small ruminant numbers in the province and the large, but not quantified, imports from Iran and Afghanistan. A small size tannery can process 1,000-2,000 skins a day, but has large water requirements; therefore, the most suitable areas for location of tanneries in highland Balochistan would be in the northern districts of Loralai and Pishin, where water is more

abundant than in Quetta, Kalat or Khuzdar districts. Because of potential fluctuations in the exchange rate of the Pakistani currency in relation to the Iranian and Afghanistan currencies, it would be more realistic to consider the feasibility of a tannery supplied with domestic skins for the domestic leather market than a tannery supplied with export quality skins for the international leather market.

Improvement of the quality of the skins produced in this area can be achieved by minimizing cuts and scars and by better nutrition. Producers should adopt good shearing practices to avoid skin damage. Increasing the protein content of the animals' diet might even increase skin thickness but would require cost-effective nutrition. Table 5.10 shows that the largest size of goat and sheep skins from Balochistan are comparable with the medium sizes from Iran or Afghanistan. Size is a combination of breed and age at slaughter and it is difficult to envisage changing the breed to give larger skins. However, size could be increased by better management and nutrition which would increase animal size at slaughter.

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Future Research

In 1992 the AE Section will make major efforts to obtain information about farmers' perceptions of water-harvesting techniques for growing cereals, and the adoption potential of this technology. Blending the stochastic analysis of the economics of cereal crops grown using water-harvesting (Khan *et al.*, 1991, p. 41-42) with the farmers' perception of this technology, will provide the necessary elements for AZRI scientists to decide the future course of action on water-harvesting research. The annual crop component of the AZRI modelling effort will allow the investigation of other aspects relevant to rural communities in highland Balochistan, either at the household level or at the tribal and communal level. These aspects are: the alternative uses of the labor surplus released by the implementation of water-harvesting techniques; design of the water-harvesting layouts to optimize cultivable land and inter-cropping patterns; the effect of improved reliability of fodder production upon the household livestock component.

The assessment of the pay-off of AZRI's research on different commodities should be based on supply and demand, not only on their production potential (supply) but also on their price and income elasticities (demand). Burney and Ahmad (1991) have shown how the estimated demand for food and fiber needs to be understood in the light of the income structure of both urban and rural inhabitants. Thus, an effort will be made to determine the food demand of highland Balochistan by the year 2000 to provide guidelines for expected returns on research.

Some research has been carried out on animal husbandry but little has been accomplished in terms of understanding the complexities associated with tribal and communal land tenure, and transhumant and nomadic livestock production systems. The assessment of these issues is very relevant to the emphasis and expectations that AZRI should have in range livestock management. Efforts will be made to identify mechanisms to ensure that pastoralists of highland Balochistan benefit from AZRI's development of range resource management strategies.

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Chapter 6

Agronomy, Water Harvesting and Camel-drawn Seed-drill

Introduction

Exploratory agronomic trials were started in 1985, and have been continued and developed since then. They are intended to provide basic agronomic data for dryland farming in highland Balochistan. The trials have mostly been conducted on farmers' fields around Quetta, so that the results should be relevant and applicable to farmers' circumstances. Also, the plots should serve as demonstrations of new techniques, and should act as focal points for discussion with farmers of agricultural problems and practices.

Agronomic research has been carried out on four main crops, wheat, barley, lentil and the forage legume woollypod vetch (*Vicia villosa* ssp. *dasycarpa*). The results in previous years indicated that modest improvements in yields could be obtained from some of the improved practices in seasons with abundant rainfall, but rarely in seasons with average or poor rains. Research on the more promising lines was continued in the 1990/91 season for rainfed conditions. In this category there are two main types of land use namely, **khushkaba**, where no run-on from outside flows on to the cropped areas, and **sailaba**, where there is some runon from flood water in higher areas, usually from ephemeral streams. Most of the agronomic trials have been carried out under khushkaba conditions, and a smaller number in sailaba fields.

The objectives of the agronomy research in 1990/91 were:

- to carry on, with modifications, the catchment basin water-harvesting (CBWH) trials which were started in 1986/87, at existing and new sites.
- to evaluate the effects of other factors such as manure and fertilizer, on the performance of wheat, barley, lentil and woollypod vetch in the CBWH trials.
- to monitor the performances of promising new lines of wheat, barley, lentils, and woollypod vetch, and combine this with seed bulking.
- to evaluate the recently developed camel-drawn seed-drill under field conditions.

Catchment Basin Water-harvesting Trials

In highland Balochistan the low probabilities of getting sufficient rain emphasize the need for technology to improve or increase water availability. In purely rainfed khushkaba land use where there is no chance of getting runoff, CBWH offers an opportunity for improving the efficiency of the limited rainfall within the field. The soils in these broad flat valleys are mostly silty clay loams or silty loams and have very poor structural stability. As soon as they are wetted the surface layer slakes and becomes muddy. Fine particles clog the pore spaces and the top wet layer becomes much less permeable to further rainfall so that runoff starts quite soon. In addition, after drying out the surface forms a crust which can become quite hard; this can severely impede seedling emergence. Due to the slow rate of infiltration through such hard crusts, the proportion of rainfall which runs off from subsequent showers is greater. These soil

characteristics give rise to potential opportunities for water-harvesting. The data in Table 6.1 summarize the physical and chemical properties of the soils on which the agronomy trials were conducted during 1990/91. In general, these soils are alluvial yermosols, light to medium in texture, high in lime percentage and pH, low to medium in available phosphate (P) content and low to very low in organic matter and nitrogen (N). The Olsen P and Kjeldahl total N values presented here suggest that responses to phosphatic and nitrogenous fertilizer might be obtained, provided that adequate moisture is available.

Table 6.1. Soil analytical data for different trial sites, 1990/91.

Location	pH	Lime (%)	Olsen P (ppm)	OM (%)	Kjeldahl N (ppm)	Texture
Quetta	8.7	32.1	6.0	0.60	415	Silty loam
Dasht	8.5	25.2	7.4	0.62	450	Silty loam
Kolpur	8.4	21.9	9.2	0.74	490	Silty clay loam
Spezand	8.5	22.8	8.1	0.83	470	Silty loam
Mastung-1	8.6	26.3	8.2	0.59	440	Silty loam
Mastung-2	8.9	27.2	6.4	0.68	422	Silty clay loam

Treatments. The water catchment treatment consists of grading and then smoothing the catchment area. The land is first graded to a uniform gentle slope of around 0.5-1.0 %, and then smoothed by dragging a heavy wooden plank over it, behind a tractor. When rain falls, a crust is quickly formed, and runoff from the smoothed catchment area takes place to the lower cropped area. In previous CBWH trials on these soils, as much as 50 % of the rainfall ran off.

This technique has been evaluated at sites in the centres of some of the broad valleys around Quetta, such as Dasht, Mastung and Kolpur, from 1986 onwards. There, the soils are heavier than the more gravelly soils near the foothills. Small earth bunds 50 cm high were made around each experimental plot, and three different ratios of catchment-to-crop areas were established in the 1990/91 trials, namely 1:1, 2:1 and 3:1. A control plot without water-harvesting was also laid down. In addition, the 2:1 and 3:1 treatments had a buffer (+B) zone added at the bottom side where surplus water could be discharged when heavy rains flooded the cropped areas and caused waterlogging. Fourwing saltbush was planted in this zone to utilise any such surplus water.

The field trials were conducted at four sites around Quetta. Each trial consisted of three replicates, with the four water-harvesting treatments as main plots. Each main treatment was split into two manure treatments, namely 5 tons/ha, or none. The manure treatments were next split for crop, either cereals (wheat or barley) or legumes (lentils or woollypod vetch). The wheat and barley were further split for fertilizer, with and without 130 kg/ha of 23:23:0 (N:P:K) fertilizer. The legume plots were not split any further. Soil samples were taken for gravimetric moisture determination at all sites; neutron probe access tubes were installed in one trial at Mastung only. The trials were set up at sites in Spezand, Kolpur, Dasht and Mastung, but only one trial, at Mastung, produced usable results; the other sites failed because of flooding and complete waterlogging in February at three sites, and problems with bad germination at the others. The poor germination was due to planting too late in December, as the rain around Quetta did not begin until just after the middle of that month. Most

of the germinating seedlings were killed by very cold temperatures which went down to -15 to -19°C in late December and early January.

Results. The results of the trial which was planted in late January at Mastung are shown in Table 6.2. The cereals and the legumes were grown side-by-side within the main water-harvesting treatment plots, but their results were analyzed separately. The yields are expressed per hectare of cropped land.

Table 6.2. Results for cereals in CBWH trial, Mastung-2.

Treatments	Grain (kg/ha)	Total dry matter (kg/ha)	100 grain wt. (g)
Water-harvesting treatments:			
Control	117	1338	2.96
1:1	184	1664	2.92
2:1+B	144	1174	2.82
3:1+B	220	1635	2.98
Manure (t/ha):			
0	153	1445	2.83
5	180	1461	2.91
Crops:			
Wheat	152	1388	2.63
Barley	181	1519	3.11
Fertilizer (kg/ha; wheat and barley only):			
0	153	1321	2.90
130	181	1586	2.84
Overall mean	166.6	1453.5	2.87
CV (%)	44.2	15.9	12.9

The water-harvesting treatments did not have statistically significant effects, but there was a trend for them to increase the grain and total dry matter (TDM) yields. Manure and fertilizer applications also tended to increase grain yields and TDM yields, but again this was not statistically significant. However, there was a significant interaction between manure and the type of cereal, as shown in Table 6.3.

Application of manure increased grain yields of barley by 42%, but decreased wheat yields slightly. Possibly barley, being slightly more drought-resistant and earlier maturing than wheat, was able to benefit more from the manure.

The yields of the legumes were very low and there were no significant effects from the treatments (Table 6.4). There were significant interactions between the water-harvesting treatments and the TDM yields produced by the legumes, as shown in Table 6.5. The lentil responded much more to the harvested water than did the woollypod vetch.

Table 6.3. Effect of manure on wheat and barley grain yields (kg/ha) in CBWH trial, Mastung-2, 1990/91.

	Manure (t/ha)		Mean
	0	5	
Wheat	156	148	152
Barley	150	213	181
Mean	153	181	167

Table 6.4. Results for legumes in CBWH trial at Mastung-2, (January 1991 planting) (kg/ha).

Treatments:		Grain yield	Total dry matter	100 grains wt. (g)
Water-harvesting				
Control		55	226	2.60
1:1		63	288	2.62
2:1+B		51	326	2.90
3:1+B		72	486	2.79
Manure	0	60	325	2.84
(t/ha)	5	61	338	2.63
Lentil		65	425	1.66
Woollypod vetch		56	238	3.81
Overall mean		60.5	332.0	2.7
CV (%)		37.9	18.4	17.4

Table 6.5. Effect of water-harvesting techniques on total dry matter yields (kg/ha) of lentil and woollypod vetch at Mastung-2.

Treatment	Lentil	Woollypod vetch	Mean
Control	245	207	226
1:1	347	228	288
2:1+B	399	253	326
3:1+B	708	264	486
Mean	425	238	331

Camel-drawn Seed-Drill

In rainfed agriculture most of the cereal crops are sown using draft animals, mainly camels in highland Balochistan. One of the most important means of assisting such areas is the development, adaptation and evaluation of new agricultural technology that can be adopted by small farmers. Two years ago the Agronomy Section collaborated with Naeem and Co., a private agricultural machinery firm in Faisalabad, in designing and fabricating a three furrow camel-drawn seed-drill for rainfed areas of Balochistan. This drill can work easily in both large and small plots.

To compare this new camel-drawn seed-drill with the traditional wooden

camel plough, field plots were established at Spezand, Kolpur and Mastung (two plots) At each location the plots were sown in mid-December, 1990. The design was a randomized complete block design with 4 replications, and the crops sown were local wheat and improved barley (Arabi Abiad), without fertilizer. Land preparation, seed rate and seeding depth for both the improved and the traditional plough were kept constant. The yields of TDM and grain are shown in Table 6.6.

Table 6.6. Total dry matter (TDM) and grain yields from wheat and barley planted by improved seed-drill and camel plough (kg/ha).

Site	TDM	Grain
Spezand	1883	451
Kolpur	1899	507
Mastung-1	1860	525
Mastung-2	1530	471
Wheat	1771	468
Barley	1814	509
Camel-drawn seed-drill	1887	518
Local camel plough	1698	459
Overall mean	1793	489
CV (%)	6.4	5.8

Statistical analysis indicated that there were significant ($P<0.05$) differences among sites for both TDM and grain yields. Planting with the improved seed drill gave a significantly higher TDM and grain yield than local plough-planting. Also, barley grain yields were significantly ($P<0.05$) better than wheat yields. There were no significant interactions. These results indicate that the improved seed drill was slightly better than local plough-planting and that it gave similar results with both wheat and barley.

Measurements of the time taken for planting by each method were carried out and the seed-drill took approximately half the time that the traditional plough took to plant a similar area. Such a saving in time would enable farmers to plant their whole area within a shorter time when conditions were favourable, or alternatively to plant a larger area.

There are various aspects of the drill which still need to be improved; it appears to be rather heavy, and is difficult to turn at the end of each row; the on/off control lever is badly positioned and could injure the operator; transport from field to field is likely to be slow and laborious; and the single wheel in the middle seems less stable than a wheel at each side would be. These problems have been taken up with the manufacturer in Faisalabad to get further improvements incorporated in the next model, which should be ready for testing in February, 1992. The drill cost Rs6000 in November 1988 and current costs of production need to be ascertained.

An informal survey to find out if there was any potential for fabricating such simple types of agricultural machinery locally in Quetta indicated that the necessary skills and resources have not yet been developed in the small local embryonic agri-business sector.

Wheat and Barley Observation and Seed Multiplication Plots

Some selected wheat and barley lines were provided by the Germplasm Section for field observation and seed bulking by the Agronomy Section. Punjab 85 and Zamindar were obtained from the Seed Certification Corporation, Punjab through ARI Sariab, while the other genotypes came originally from ICARDA for evaluation by the Germplasm Section. These lines were planted in unreplicated plots in a sailaba field at Kolpur without any fertilizer, to observe their cold tolerance, and drought and disease resistance under field conditions. The data are shown in Table 6.7. Encouraging grain yields were obtained from Punjab 85, WAT86-620 and WAT86-1007. The barleys outyielded the wheats, and promising yields were obtained from W1291/12269 and Wadi Hassa.

Table 6.7. Total dry matter (TDM) and grain yields (kg/ha) of wheat and barley seed plots in a sailaba field at Kolpur.

Entry	TDM	Grain	Amount of seed produced (g)
Wheat			
Punjab-85	633	295	649
WAT86 603	273	121	267
WAT86 613	348	187	410
WAT86 620	486	229	504
WPT86 913	387	179	393
WAT86 923	392	188	415
WAT86 1003	349	157	345
WAT86 1007	453	208	459
Soreviki	256	114	252
Kahani	283	133	292
Zamindar	99	43	95
Sonalika	61	30	65
Local Wheat	21	11	23
Barley			
W1291/12269	1566	730	379
Wadi Hassa	1269	705	378
Arabi Aswad	1113	522	268
Arabi Abiad	1289	454	256

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Chapter 7

Germplasm Evaluation

Introduction

Abiotic and biotic stresses are the main limiting factors that adversely affect rainfed crop yields in highland Balochistan. Winter crops mainly suffer from cold, drought, and fungal diseases; yellow rust *Puccinia striiformis* is generally serious in years with high rainfall. Occasionally viral diseases such as barley yellow dwarf virus cause damage. Both spring and fall sown crops usually suffer terminal drought coupled with heat stress. Local cultivars are well adapted to the prevailing environmental conditions, but their yield potential is low and they are susceptible to fungal diseases whenever there is a good rainfall season. It is therefore important to introduce and evaluate new and exotic germplasm with the potential for high and stable biomass production and grain yield, coupled with stability and improved disease resistance.

Materials in germplasm collections are the basic source of genetic variability. Crops currently under evaluation in the Germplasm Section are bread wheat, barley, lentils and forage legumes. The evaluation and selection program aims at improving the food and forage output of highland Balochistan, and reducing the risk associated with growing rainfed crops in this extremely marginal environment.

In 1990/91 trials were conducted at several locations with fall and spring plantings. The use of a wide range of environments facilitates thorough screening and selection of desirable genetic material which should then be well adapted to the harsh environmental conditions in these areas.

The objectives of the germplasm research are:

1. To select well-adapted, disease-free and resistant crop species, lines, and genotypes which yield more than, or at least as much as, local cultivars but with less variation. They should be acceptable, and suitable for growing under non-irrigated conditions; improved genotypes of crops other than wheat would enable farmers to diversify away from the wheat mono-cropping system which is commonly followed in highland Balochistan.

2. To assess the possibilities for producing additional livestock feed in the highlands from the introduction of forage crops, or from the additional crop residues from higher-yielding food crops grown under rainfed conditions.

This report summarises the results of the 1990/91 season from the germplasm evaluation and screening program at AZRI. Full details are contained in MART/AZR Research Report No. 73, ICARDA, Quetta.

Materials and Methods

The germplasm evaluation trials were conducted at the four locations shown in Table 7.1. They are selected to provide a representative cross-section of the agroecological conditions in the rainfed cropping areas of highland Balochistan. ARI is the Agricultural Research Institute, Sariab Road, Quetta, about 10 km south of AZRI.

Table 7.1. Germplasm testing sites in highland Balochistan

Site	Altitude (m)	Latitude	Longitude
ARI, Sariab, Quetta	1690	30° 07'N	66° 58'E
Loralai, Kili Bokhara	1340	30° 24'N	68° 36'E
Kalat, Kili Ahmadabad	1850	29° 07'N	66° 24'E
Kan Mehtarzai	2250	31° 00'N	67° 45'E

Nine barley, seven bread wheat, five lentil and five forage legume trials were conducted at these sites. To ensure satisfactory germination, without which it is difficult to evaluate the material, a pre-soaking irrigation was applied at Quetta, Kalat and Kan Mehtarzai for the fall planting. At Loralai, the trials were planted on conserved moisture from earlier monsoon rains; however, during the winter season there was very little rain and a supplemental irrigation had to be applied to save the germplasm at that site. Spring trials were conducted on conserved moisture from winter rains and no additional irrigation was applied at Quetta and Kalat. NPK fertilizer was used at rates of 60:60:0 kg/ha for cereals, and 0:60:0 kg/ha, plus *Rhizobium* inoculum, for the legumes.

Randomized complete block designs were used for the yield trials; each entry had 6 rows/plot, and the rows were 5 m long and 0.25 m apart, which gave a plot size of 7.5 m^2. However, at Loralai the plot size was 6.6 m^2 (4 rows/plot, row length 5.5 m and row spacing 0.3 m). Plants were hand-harvested at the end of May at Loralai and in mid-June at Quetta, Kalat and Kan Mehtarzai. Growth habit (erect, prostrate, intermediate), cold tolerance (scale 1-5), heading date (days from planting), plant height, and disease resistance (yes/no) were recorded before harvest. Data on biological yield, that is total dry matter (TDM), and grain yield, and 1000 kernel weight were taken after harvest. The MSTAT.4C statistical package was used to analyze the data.

Climatic Conditions

The salient meteorological data for the four sites are shown in tables 7.2 and 7.3. During the 1990/91 cropping season precipitation was well above average at Quetta and Kan Mehtarzai, and as it came in late winter and early spring it provided sufficient moisture for both fall and spring sown crops at Quetta. No severe frost or cold damage was observed in these trials. Moreover, the Quetta site has been very favourable for screening materials for yellow rust resistance for the last two consecutive seasons as the high rainfall and humidity promoted severe fungal attacks which visibly affected many farmers' fields in the vicinity.

At Kan Mehtarzai the rainfall was above normal. Heavy snowfall occurred in winter and crops were under a blanket of snow during the coldest months; this reduced vegetative growth but helped crops to escape cold damage. At Kalat (Kili Ahmadabad) the monsoon rains were scanty (13 mm). Winter rain started in late November and continued up to April. Total seasonal precipitation was slightly above average. At Loralai (Kili Bokhara) the monsoon rains were better (44 mm) than at the other sites, but from October to January rain was scarce and crops came under stress at the tillering stage. No frost and cold damage was observed at this site.

Table 7.2. Climatic data at Quetta (ARI) and Kalat, 1990/91.

	Quetta, ARI			Kalat, Kili Ahmadabad		
	Rainfall (mm)	Temperature[1] Max.	Temperature[1] Min.	Rainfall (mm)	Temperature[1] Max.	Temperature[1] Min.
July,1990	0.0	35.8	17.4	0.0	32.9	15.2
August,1990	0.5	35.1	18.6	13.0	32.0	16.4
September	0.3	30.6	11.1	0.0	29.5	10.5
October	0.0	24.0	4.0	0.0	21.8	3.0
November	0.0	18.6	1.0	0.4	17.2	0.4
December	22.4	11.3	-0.5	28.3	7.8	-4.3
Jan. 1991	80.0	8.4	-1.1	60.2	9.1	-2.5
February	78.2	10.8	-0.4	65.2	10.2	-0.2
March	103.2	15.6	4.4	63.1	14.8	2.9
April	39.2	22.1	7.3	19.1	20.6	8.0
May	19.3	27.5	12.9	0.0	27.0	10.9
June	0.0	32.9	15.4	0.0	31.6	13.2
Total	343.5			249.3		
Irrig.[2]	50.0			50.0		

[1]Screened air temperature at 1.5 m.
[2]Applied as one supplemental irrigation before sowing.

Table 7.3. Climatic data, Loralai and Kan Mehtarzai, 1990/91.

	Loralai			Kan Mehtarzai		
	Rainfall (mm)	Temperature[1] Max.	Temperature[1] Min.	Rainfall (mm)	Temperature[1] Max.	Temperature[1] Min.
July, 1990	-[2]	-	-	0.0	32.4	16.5
Aug. 1990	28.4	26.0	23.2	15.4	31.3	15.4
September	15.6	22.2	20.0	0.0	28.5	11.4
October	0.0	20.3	11.0	0.0	21.5	4.5
November	0.0	24.0	6.0	0.0	16.3	2.2
December	1.6	16.0	1.3	85.4	7.8	-3.4
Jan. 1991	1.6	11.0	-0.1	171.4	4.6	-0.6
February	13.6	16.4	3.0	80.4	-	-
March	50.5	21.0	7.1	105.1	-	-
April	30.4	25.0	8.0	70.6	21.4	10.9
May	0.0	33.9	16.1	12.0	-	-
June	0.0	40.3	19.1	0.0	-	-
Total	141.8			540.3		
Irrig.	150.0[3]			50.0[4]		

[1]Screened air temperature at 1.5 m.
[2]Data not available.
[3]Applied as one supplemental irrigation at tillering.
[4]Applied as one supplemental irrigation before sowing.

Results and Discussion

This season the material was divided into two categories, namely selections from previous years and new material used in yield trials and observation nurseries. Most of the new material was received from ICARDA, and some from CIMMYT. Significant differences refer to the $P<0.05$ level. The year of the first selection of the material is shown in parentheses after the heading of each sub-section.

Barley

Barley Yield Trial Selection (Winter 1988/89): 19 selected barley genotypes from four trials first conducted in 1988/89, were planted at Quetta, Kalat and Loralai in the fall, 1990. Due to the good rainfall, no drought stress was experienced at Quetta at important growth and developmental stages. However, moisture deficiency was experienced at Loralai during early vegetative growth. Biotic stresses were not severe at Quetta and Kalat, but at Loralai genotypes BKL88 208 and BKL88 372 were infected with loose smut, (*Ustilago nuda*). Due to the high rainfall at Quetta most genotypes lodged, which caused some reduction in grain yield. At Kalat and Loralai the plant populations were not uniform due to uneven soil moisture, thus the estimation of yield potentials for the different genotypes was adversely affected. Frost and cold damage was not observed at any site.

Some exotic genotypes yielded significantly more grain than the local landrace check, as in the previous year, but no differences were observed in total dry matter (TDM) yields at all the sites in contrast to the previous year's results (Ahmad *et al.*, 1990a). At Quetta, the grain yields of genotypes BOC87 92, BOC87 34, BYL88 11, BKL88 49 and BYL88 6 were significantly higher than the local check. In last year's trial at Quetta, the above-mentioned entries were not significantly different from the local check in terms of grain yield, whereas genotypes BOC87 92, and BYL88 11 did outyield the local landrace at Loralai (Ahmad *et al.*, 1990a). This trial will be repeated for another year at the same sites so that final conclusions can be made; selected entries will then go forward into agronomy trials.

Barley Yield Trial Selection (Winter 1989/90): five barley lines (BYC88 1, BYC89 16, BYC89 17, BYC89 19, and BOC89 53), selected from the 1989/90 trials (Ahmad *et al.*, 1990a) on the basis of winter hardiness, drought tolerance, disease resistance and yield, were planted at Quetta, Kan Mehtarzai and Loralai in the fall, 1990.

All these lines survived at the higher elevation sites of Quetta and Kan Mehtarzai and showed good winter hardiness and resistance to freezing temperatures. At Kan Mehtarzai the crop was under snow cover for three months; this retarded the vegetative growth during the winter months and thus TDM and grain yields were lower than in Quetta. At Kan Mehtarzai grain yield was also reduced by bird damage which was more severe on exotic lines due to their earlier heading and maturity than on the local check. At Loralai genotype BOC89 53 was affected by leaf spot *(Septoria nodorum)* in its early vegetative stages. However, the disease was not observed at the reproductive stage. The TDM differed significantly among genotypes at both Quetta and Kan Mehtarzai; grain yield differences were not significant at any sites, just as in the previous year.

Barley Yield Trial Selection (Spring 1988/89): 13 exotic lines of barley selected from the 1988/89 trials (Ali *et al.*, 1989) were planted at Quetta and Kalat in spring, 1991. At Quetta rainfall was high during the spring season and therefore no terminal moisture stress was observed. However, at Kalat the terminal moisture stress was severe and grain yield was comparatively low.

There were significant differences in TDM and grain yields at Kalat. Genotype BYL88 6 produced significantly higher TDM than the local check, and five genotypes (BYL88 6, BYL88 18, ABU88 151, ABU88 162 and ABU88 152) gave significantly higher grain yield than the local check. Genotype BYL88 18 behaved in the same way at Kalat last year (Ahmad *et al.*, 1990a). These

results showed that environmental stresses can be lessened by selecting genotypes better suited to the season and rainfall distribution.

Barley Yield Trial Selection (1986/87): four selected Syrian barley landraces (Arabi Abiad, Arabi Aswad, Wadi Hassa, and Tadmor) were compared with the local barley in spring planting for the fourth year at multiple sites in highland Balochistan (Ali and Ahmad, 1989; Ali *et al.*, 1989; Ahmad *et al.*, 1990a). This was the last year of testing, and these landraces have now been evaluated under a wide range of different environmental stresses.

This year there were no significant differences between genotypes in TDM and grain yields at both sites, although Wadi Hassa had given significantly higher grain yields than the others in the 1989/90 season at Quetta (Ahmad *et al.*, 1990a). All these landraces mature earlier than the local check and thus have a better chance of escaping terminal drought. Terminal moisture stress is a major constraint on the yields of spring-sown crops in this area (Ahmad *et al.*, 1990b); by selecting such short duration and early maturing lines instead of longer, later types, it is possible to make more effective use of moisture available during the crop growth period. The data will be combined across sites and years and after a stability analysis has been made, final conclusions will be drawn.

Barley Yield Trial Selection (Spring 1989/90): five barley lines were chosen from the 1989/90 trials on the basis of their growth vigour, early maturity and yield potential (Ahmad *et al.*, 1990a), and were planted in spring 1991 at Quetta and Kalat.

The genotypes differed significantly in TDM at both sites. At Quetta, the TDM of the selected lines was not significantly higher than the local check. At Kalat genotypes BYL88 18, and BOL87 75 produced significantly higher TDM than the local check. Three genotypes (BYL88 18, BOL87 66 and BOL87 75) gave significantly higher grain yield than the local barley landrace at Kalat. The testing of these lines will be continued.

Barley Yield Trial (High Altitude 1990/91): genetic variability is the basis for making selections for any target environment. To broaden the genetic variability, 23 new exotic barley genotypes were introduced and tested at Quetta, Kan Mehtarzai and Loralai.

At Quetta two genotypes (PBT190 6 and PBT190 7) produced significantly higher TDM yields than the local check, whereas at Kan Mehtarzai and Loralai the TDM yield of exotic barley genotypes was not significantly better than the local barley landrace. At Quetta 15 genotypes (BYC90N 7, BYC90N 8, RBYT90 15, PBT190 6, BYC90N 6, PBT190 7, BYC90N 23, BOC89N 4, BYC90N 12, BOC89N 15, BOC89N 26, BOC89N 34, BOC89N 41, BOC89N 82 and BOC89N 79) gave significantly higher grain yields than the local check. These genotypes have been selected for further testing.

Barley Yield Trial (Low rainfall and Cold winter 1990/91): 23 new exotic barley lines were planted at Quetta, Kan Mehtarzai and Loralai in fall 1990. At Quetta some genotypes lodged at the heading stage due to excessive vegetative growth. The grain yield at Kan Mehtarzai was lower than at the other sites due to bird damage.

At Quetta two genotypes (BYC90N 6 and BYC90N 12) produced significantly higher TDM yields than the local check. On the other hand, at Kan Mehtarzai and Loralai the TDM yield of exotic lines was not significantly better than that of the local check. At Quetta ten genotypes (BYC90N 1, BYL90N 16,

BYL90N 21, BYC90N 12, BOL89N 68, BOL89N 34, BOM90N 71, BOL89N 22, BOL89N 89 and BOL89N 62) gave significantly higher grain yields than the local check. No significant differences were observed at Kan Mehtarzai and Kalat. All these ten high yielding lines have been selected for further testing.

Barley Observation Nurseries (Winter 1990/91): two sets of observation nurseries were planted in the fall, 1990. The first nursery was the International Winter and Facultative Barley Observation Nursery consisting of 150 entries. The other Barley Observation Nursery - Low Rainfall and Cold Winter, consisted of 58 entries. These two nurseries were evaluated both at Quetta and Loralai. Observations were made on growth habit, cold tolerance, days to heading, plant height, disease resistance, and yield parameters. On the basis of desirable traits 10 genotypes were picked from these nurseries for further testing at multiple sites in highland Balochistan.

Bread Wheat

Bread Wheat Yield Trial Selection (Winter 1989/90): this trial included 26 genotypes of different origin and was planted in winter 1990/91 at Quetta, Kalat and Loralai. Materials were screened and evaluated for cold, drought and disease resistance. At Quetta there was no severe cold or frost damage to the wheat genotypes.

Significant differences in TDM and grain yield occurred at Kalat but not at the other two sites. At Kalat, genotypes W3918A/JUP, WOL87 50, WAT87 209, IWON87 209, PWSN87 419, and WBWON84 111 gave significantly higher TDM yields than the local check. The grain yields of lines WOL87 50, WAT87 209, IWON87 209, PWSN87 335, PWSN87 419, WPT87 621, WPSN87 711, W3918A/JUP, and ICW81 1673 were all superior to the local check. Promising lines will be included in next year's trials.

Bread Wheat Yield Trial Selection (Spring 1989/90): 14 different genotypes selected from trials in the previous year (BWYT-H.A. and BWYT-LR 1988/89) were compared with four local checks and (Syrian) Sham-4, at Quetta and Kalat.

TDM yield differed significantly among the exotic genotypes but none outyielded the four checks at Quetta. There were no significant differences in grain yields. Last year, similar results were obtained (Ahmad *et al.*, 1990a). This experiment will be repeated for another year to obtain more data on the adaptability and yield potential under drought and heat stress of these selections.

Bread Wheat Yield Trial Selection (Spring 1989/90): five genotypes (WOL88 14, WOL88 83, WOL88 110, WAT87 105, and WAT87 305), selected from BWON (LR) 1988-89 and BWYT-LR 1989/90 were compared with five local checks. No exotic entry was significantly better in TDM and grain yield than any of the checks. At Kalat, Zamindar significantly out-yielded nearly all the other entries, both exotic and local, but the yields there were very low.

Bread Wheat Yield Trial (Low Rainfall 1990/91): 23 exotic lines for low rainfall conditions received from ICARDA this year were planted along with a local check in winter, 1990.

At Quetta, eight genotypes (WOL89 69, WOL89 84, WOL89 107, WOL88 38, WOL89 21, WOL89 52, WOL89 98, and WOL89 109) exceeded the local check in TDM yield. At Kalat, 16 entries produced significantly more TDM than the local

check. No grain yield differences were observed at any sites. However, six genotypes (WOL89 52, WOL89 73, WOL89 81, WOL89 98, WOL89 107, and WOL89 109) have been selected for further testing due to their relatively high yield and resistance to yellow rust.

Regional Bread Wheat Yield Trial (Low Rainfall 1989/90): this trial, repeated from last year, included 23 exotic genotypes plus the local check, and was planted only at Quetta in winter, 1990.

Out of these genotypes, two (WOL88 70 and WOL88 72) produced significantly higher TDM than the local wheat landrace. Fourteen genotypes outyielded the local check in grain yield. Moreover, no yellow rust was observed on these lines. This material, received from ICARDA, Syria, has been tested for the first time under cold conditions. Therefore, all these lines have been retained for future multilocation testing in winter.

Bread Wheat Yield Trial (Winter 1990/91): ICARDA wheat breeders sent this material because of its good performance under environmental conditions similar to highland Balochistan. The trial, with 48 entries, was planted at Kalat in the fall, 1990.

Although only one line (WCI 90 101) significantly exceeded the local check in grain yield and harvest index, the material will be tested again at a wider range of germplasm screening sites in highland Balochistan.

Wheat Observation Nurseries (Winter 1990/91): two different sets of observation nurseries from ICARDA were evaluated for desirable traits: a) 6th International Winter Wheat Screening Nursery consisting of 137 entries and b) Regional Bread Wheat Observation Nursery - High Altitude consisting of 150 entries. Parameters were recorded on growth habit, cold tolerance, disease resistance and yield potential, and 84 high yielding and disease resistant genotypes were picked from these observation nurseries for next year's multilocation trials.

Lentil

Lentil Yield Trial Selection (Winter 1988/89): as local lentils have very small seeds, an important aim is to identify larger-seeded types which yield well and are winter-hardy, disease-resistant, and tolerant to drought and heat. Nine large-seeded selected lines from the 1988/89 trials were again compared with local lentil at Quetta, Kalat and Loralai.

The TDM yield differed significantly only at Loralai, where the two genotypes ILL 5582 and ILL 5876 outyielded the local check; the others were all as good as the local. Grain yields of the exotic genotypes were not significantly superior to the local check at Quetta and Kalat. However, one genotype, ILL 5582, gave a significantly higher grain yield than the local landrace at Loralai. In the previous (1989/90) season, the TDM and grain yields of the exotic genotypes did not significantly exceed the local check at Quetta and Loralai (Ahmad *et al.*, 1990a). In both years, a severe attack of army-worm at the pod formation and seed-setting stages considerably reduced grain yields at Loralai. Therefore, valid comparisons for grain yield at that site were not possible. However, the larger grain and higher grain weight of these exotic genotypes is an advantage over the local landrace with its ultra small grain. This trial will be repeated for another year to confirm the performance of these genotypes in different agro-ecological zones of Balochistan.

Lentil Yield Trial Selection (Winter 1988/89): nine winter genotypes were selected from the 1988/89 observation nurseries and planted at Quetta, Kalat and Loralai in winter, 1990. TDM and grain yield did not differ significantly among the genotypes across the trial sites. Similar results were observed in the 1989/90 season at Quetta (Ahmad *et al.*, 1990a). Most genotypes showed good winter hardiness and disease resistance in both years, but the grain yield was very low at Loralai due to the severe army-worm attacks.

As this material has desirable characteristics such as larger grain size and weight along with cold and disease resistance, the material will be tested for another two years.

Lentil Yield Trial Selection (Spring 1988/89): six spring genotypes were selected from the 1988/89 observation nurseries and planted at Quetta and Kalat in spring, 1991. During the 1989/90 season these genotypes were planted at Quetta only and ILL 6260 gave a better yield than the local check, although the difference was not statistically significant (Ahmad *et al.*, 1990a).

The TDM and grain yields of the selected genotypes were not significantly better than the local check. However, the exotic genotypes mature earlier than the local check, and thus have an advantage in escaping terminal moisture stress. Testing of these genotypes will continue.

Lentil International Yield Trial (Early 1990/91): 15 new exotic genotypes of different origin were planted at Quetta and Loralai in the fall, 1990 for comparison with local lentil in terms of cold, drought and disease resistance, and yield potential.

Two genotypes (ILL 2573 and ILL 6458) showed good winter hardiness, whereas the others were damaged by frost and freezing temperatures. However, in spring all these genotypes recovered and exhibited good regrowth. The TDM yield of these newly introduced genotypes was not significantly higher than the local check at Quetta and Kalat. ILL 6818 gave significantly higher grain yield than the local check at Quetta. At Loralai the severe army-worm attack reduced yields considerably. This trial will be repeated next season with both fall and spring planting.

Lentil Yield Trial (Winter 1990/91): this trial, consisting of ten new genotypes, was conducted with fall planting at Quetta, Kalat and Loralai. All the genotypes survived winter at Quetta and Kalat and no severe frost and cold damage was experienced.

Seven genotypes (ILL 465, ILL 468, ILL 590, ILL 662, ILL 5684, ILL 5725 and ILL 6777) at Quetta and four genotypes (ILL 468, ILL 5684, ILL 6245 and ILL 6777) at Loralai produced significantly higher TDM yields than the local landrace. In the case of grain yields, at Quetta five genotypes (ILL 5599, ILL 5684, ILL 5725, ILL 6245 and ILL 6777) outyielded the local check, three of them (ILL 5599, ILL 5684, ILL 5725) yielding substantially more. However, at Kalat and Loralai, the grain yields of exotic genotypes were not superior to the local landrace. A severe attack by army-worms affected grain yield at Loralai. Testing of these genotypes will continue.

Forage Vetch

Woollypod Vetch Yield Trial Selection (Winter 1988/89): eight genotypes of woollypod vetch (*Vicia villosa* ssp. *dasycarpa*) selected from the 1988/89 trials, were compared with local lentil and the improved check of woollypod vetch, Acc. no. 683, at Quetta and Kalat.

All wooll

ypod vetch (WPV) genotypes at Quetta produced significantly higher TDM yields than the local lentil. However, TDM yield was not significantly better than the improved check Acc. no. 683, just as in 1989/90 (Ahmad *et al.*, 1990a). Similarly, during the 1988/89 season TDM yield did not differ significantly between genotypes at each of the trial sites (Ali *et al.*, 1989).

Grain yield differences were significant at Quetta and Kalat. WPV Acc. no. 956 gave significantly higher grain yield than the local check at Quetta. At Kalat the local lentil landrace significantly outyielded the WPV genotypes. However, during the previous (1989/90) season an entirely different set of entries of WPV (Acc. nos. 596, 717, 800, 958, 966, 2558, and 683) had given significantly higher grain yields than the local check (Ahmad *et al.*, 1990a). These genotypes will be tested for another year.

Bitter Vetch Yield Trial Selection (Winter 1988/89): twelve selected genotypes of bitter vetch (*V. ervilia*), another promising forage legume, were tested both in fall and spring plantings at various sites using materials selected in 1988/89. Local lentil was used as the check.

In the fall and winter plantings, TDM yield of bitter vetch genotypes was not significantly better than the local lentil. All bitter vetch genotypes gave significantly higher grain yield than the local check at Quetta. At Kalat, eight genotypes gave significantly higher grain yield than the local check (Acc. nos. 225001, 225004, 225008, 225010, 225012, 225014, 225015 and 225007.)

Seven genotypes (Acc. nos. 225004, 225007, 225010, 225015, 225006, 225011, and 225014) at Loralai were significantly better in grain yield than the local check. Similarly during the 1989/90 season the performance of these genotypes was superior at Quetta when compared to the local check (Ahmad *et al.*, 1990a).

In the spring planting at Kalat, seven genotypes (Acc. nos. 225001, 225008, 225010, 225007, 225011, 225014, and 225015) produced higher TDM yields than the local check. There were no significant differences at Quetta. The grain yields of bitter vetch genotypes were significantly better than the local check at Quetta and Kalat. At Quetta all the genotypes gave significantly higher grain yields than the local check; Acc. no. 225016 was the lowest. Nine genotypes (Acc. nos. 225001, 225006, 225008, 225010, 225011, 225014, 225015, 225004, and 225012) at Kalat gave significantly higher grain yields than the local check. Fall and spring testing of these genotypes will continue.

Collaborating AZRI Staff: M. Anwar Khan, Sarfraz Ahmad, Irshad Begum, and S.A. Jaleel

ICARDA Advisor: A.Y. Allan

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Chapter 8

Staffing Matters, Training, Workshops, Consultancies

AZRI Staffing Difficulties

As mentioned in Chapter 1, AZRI still suffers from acute under-staffing in the Range, Livestock, Agricultural Economics and Extension Sections due to the absence of scientists on long-term training (LTT). In contrast, the Agronomy and Germplasm Sections are now relatively well staffed. The recruitment of Dr Usman Mustafa to the Economics Section is a welcome development. However, the short-term consultancy in that Section will end in early 1992, leaving it very weak once again. Annex 2 shows the staffing in the various Sections on December 31, 1991.

Long-term Training

During 1991 two AZRI staff returned from LTT sponsored by MART. Mr M. Anwar Khan, Scientific Officer in the Germplasm Section, completed a MS at Montana State University with a thesis on the "evaluation of cytoplasmic male sterile hybrid barley in hill plots". Mr Babar Raza Kazi, Senior Scientific Officer from AZRI Sub-station Umerkot, returned from New Mexico State University after completing a MS. He will be posted again to AZRI Sub-station Umerkot. This brings to three the number of AZRI scientists who have completed graduate degrees sponsored by MART.

Mr Ghulam Akbar, Deputy Director at AZRI Sub-station Bahawalpur, left for the USA in September to start LTT sponsored by MART. He started courses towards a PhD degree at Utah State University and will prepare a research proposal to work on the two perennial grasses common in northern Balochistan, *Chrysopogon aucherii* and *Cymbopogon shoenanthus*. This will make his research particularly relevant to the rangeland problems of Balochistan. It will also complement the research of Dr Mohammed Salim, now Divisional Forestry Officer at Khuzdar, who obtained his PhD degree in the same department at Utah working on these two grass species. Hopefully Mr Akbar will conduct some of his research at AZRI's Tomagh station near Loralai.

It is an essential part of AZRI's policy to ensure that staff members taking graduate studies spend at least one season conducting research in Balochistan. This has two clear benefits: it helps ensure that the research is directed towards solving local problems, and it prepares the staff members for the research environment they will face when they return to AZRI.

The names and details of the remaining AZRI LTTs is shown in Table 8.1.

In-house Training

In-house training of AZRI staff has been given particular priority during the year. The staff in the Economics Section have learnt how to use the SPSS computer package and staff in the Livestock Section are in the process of learning this package.

Table 8.1. Names and details of remaining AZRI LTTs.

Name	University	Degree	Topic	Start year	End year
1. Kanwar Nasir	Ohio State	PhD	Vet. science	1988(9)[1]	1993
2. Zahid A. Qureshi	Arizona State	MS	Plant nutrition	1989(12)	1993
3. Asghar Ali	Colorado State	MS	Plant breeding	1990(9)	1992
4. Khalid Mahmood	Oklahoma State	PhD	Ag. economics	1990(12)	1994
5. Atique-ur-Rehman	Western Australia	PhD	Ruminant nutrition	1991(1)	1995
6. Ghulam Akbar	Utah State	PhD	Range science	1991(9)	1995

[1]Departure month.

Short-term Training

Mr Bilal Chaudhry, Scientific Officer in the Extension Section, completed in August his course on the "Training of Trainers". The course was sponsored by MART and had three phases, with one at Peshawar, one at the National Agricultural Research Center in Islamabad, and finally, one at Petit Jean Mountain, Winrock International Headquarters near Little Rock, Arkansas.

Mr Ahmad Samiullah, Scientific Officer in the Agronomy Section, completed a nine-month course funded by MART for scientific staff wishing to proceed to take a graduate degree in the USA. The course covered English Language and revision of basic sciences and mathematics.

Mr Shahid Mirza, the AZRI Senior Photographer, attended in November a one week course on audio-visual (A/V) techniques held at the A/V Unit, National Agricultural Research Center in Islamabad. In 1992 he will use his skills to help prepare an A/V module called "Welcome to AZRI".

Overseas Workshops

Mr K.N. Babar, AZRI Deputy Director and Head of the Agronomy Section, and Dr Usman Mustafa, Scientific Officer in the Economics Section, attended the Dryland Resource Management Program workshop held in Amman, 11-14 November. The workshop was organized by the Farm Resource Management Program of ICARDA and aims to bring together scientists from several NARS to discuss case studies they are working on. The two AZRI staff presented a case study on the AZRI water-harvesting studies and at the follow-up workshop, planned for 1993, they will present the results of a more detailed agronomic and economic analysis.

Seminars

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

November 7, 1991: Dr E.F. Thomson (ICARDA Team Leader): Farming Systems Research -is it still relevant? This seminar attempted to maximize audience participation: after a 10 minute introduction the presenter asked the

audience to comment or ask questions about the seminar topic. A lively discussion followed which allowed many topics to be discussed.

November 26, 1991 : Mr K.N. Babar and Dr Usman Mustafa: a report on their presentation at the Amman workshop, mentioned above.

December 3, 1991: Mr Prince Nisam from ARI Sariab gave a seminar on "Wheat Technology in Pishin district, an Econometric Approach".

Consultancies

Short-term consultancy: Mr Imran Ali was employed throughout the year as short-term consultant funded from MART/AZR in the AZRI Agricultural Economics Section. The consultancy is enabling the Section to carry out the skin marketing survey in highland Balochistan and to carry on the recently initiation two year study of small ruminant prices in Quetta market. The consultancy will end on January 31, 1992.

Short-term consultancy: Mr Ahmad Chaudhry was employed for a four-week consultancy on agri-business in June/July 1991. Some highlights of the consultancy are presented below. Full details are found in MART/AZR Research Report No. 72.

Objectives of the consultancy were: 1. to assess the scope of the agri-business sector in highland Balochistan, 2. to bring to the attention of relevant agri-businesses in Balochistan, Punjab and Sindh technologies developed at AZRI that may have commercial potential, 3. to identify problems facing agri-businesses that could be investigated by AZRI and thereby increase the value of agricultural and livestock commodities to producers, 4. to present the recommendations of the consultancy at a seminar attended by officials from provincial government departments and local trade and industry, AZRI staff and farmers, and 5. to write a report on the consultancy, including recommendations to assist AZRI in developing its links with the agri-business sector.

In the past most agricultural research was confined to research institutes and stations but with the introduction and adoption of the concept of Farming Systems Research efforts are being made to involve farmers in research to solve their problems. However, until recently agri-business has been poorly integrated into the research process. The GOP has also recognized the potential role of agri-business in agricultural research and development, and in the production, marketing and processing of farm commodities. Therefore, one objective of GOP policy is to develop mechanisms and implement policies to increase agri-business participation in the identification of problems, in research to solve these problems and in the dissemination of research results.

About two-thirds of Pakistan is arid or semi-arid and several of the technologies being developed at AZRI are relevant to these areas of the country where there is no water for irrigation. Just a small improvement in range offtake and agricultural output would have a significant impact on the overall economy of Balochistan. AZRI's research on improved forages, particularly on fourwing saltbush, has definite commercial potential. Improved varieties of wheat would reduce the area that farmers now have to sow to cover their household requirements, and that would release land for forage crops. However, commercial seed production is likely to be on a small

scale. The camel-drawn seed-drill is an attractive innovation since it could reduce the time needed to sow crops, increase crop yields and expand the area which could be planted. AZRI has technologies with commercial potential, and strengthening the linkages with agri-business will enable these technologies to reach the pastoralists and farmers of Balochistan. However, the technologies need further testing, tuning and on-farm verification so that their potential for adoption by farmers can be determined. Agri-business will then be in a better position to decide on the commercial viability of the technologies.

What can agri-business do for research? The success of agri-business has been demonstrated by the pesticide, poultry, leather and carpet industries. Many agri-businesses have their own farms and they can conduct research to verify research findings, such as the Pakistan Seed Corporation at Lahore and Lever Brothers in Karachi. Public sector research institutions (PSRI) usually have limited resources and are not involved in industrial scale production and marketing. They should be looking to agri-business to fund research on problems identified by agri-business, and incentives such as accelerated promotion should be given to scientists in PSRI who conduct research sponsored by agri-businesses.

Agri-businesses can also bring their problems to PSRI who often have the specialist expertise to find solutions to these problems. This helps research become oriented to problem solving. An example here is the skin and wool industries which have indicated that the quality of the raw material from Balochistan is often poor. They would like to see research conducted into ways of improving quality of this raw material.

Agri-business will also be prepared to pay PSRI for new technologies that have commercial potential. An example here is the MILK PAK (Lahore) contract with Nestle. Payment could be made as a 1-3% royalty for a five year period; many agri-businesses are already paying for the use of a technology and brand names. These royalties are generally paid to foreign companies but similar arrangements should be possible within Pakistan. Under the self-reliance policy of the GOP, strong linkages between PSRI and agri-business would be a useful mechanism to solve the financial constraints of these institutes.

Involvement of agri-business in specific technologies available at AZRI.
1. **Fourwing saltbush.** Private fruit nursery growers should be encouraged to grow fourwing saltbush so that they gain experience of the technique of seedling production and are ready when the market develops. AZRI could initially provide them with free seed and guidance. This effort could be complemented by the establishment of pilot demonstrations made in collaboration with the Department of Forestry and Agricultural Extension, the FAO supported Fruit Project and the UNDP Livestock-Range Management Project which starts in 1992. AZRI should create an initial demand for seedlings by purchasing them from private nurseries. 2. **Camel-drawn seed-drill.** The camel-drawn seed-drill requires further testing and demonstration on farmers' fields before agri-businesses are invited to examine it for commercial viability. 3. **Production and distribution of improved wheat, barley and lentil varieties.** Wheat seed production, particularly for rainfed areas of highland Balochistan, does not seem to have large-scale commercial potential and the area under barley and lentils provides a very limited market for improved seed. However, if the superior varieties being developed at AZRI are adopted by farmers, a demand for improved seed will arise. Small-scale seed production could be done by private seed companies who would lease land on government farms. 4. **Animal health.** There is potential for agri-business

to enter the animal health and equipment market in Balochistan. However, the major problem is the provision of medicines by government departments free of charge or at subsidized prices. This discourages agri-business from entering the market.

Recommendations for strengthening linkages between research and agri-business.

1. There is a need for a directory of agri-businesses operating in Balochistan. It would include a brief description of the company and relevant information about it. This task could be undertaken by a consultant in collaboration with AZRI, other PSRIs, and private sector institutions and departments in Balochistan. 2. Pre-feasibility studies of promising crop varieties and technologies should be conducted and sent to relevant agri-businesses in and outside Balochistan. The studies would cover market analysis, economic superiority of the new compared with the existing technology, relevant government policies, trained manpower needs, capital requirements, financial position of technology users, adjustments needed to farm systems, seasonality of demand, and support institutions. 3. Representatives of agri-business, government departments and farmers should be invited to attend field days held both at AZRI and on farmers' fields. This would provide an opportunity for AZRI to demonstrate its research portfolio. 4. The removal of government control of agri-businesses such as the seed and animal health services should be encouraged. As part of the privatization policy, government farms should be leased to agri-businesses for the verification and demonstration of new technologies. 5. Seminars, workshops and training courses should be organized by AZRI to create awareness of new technologies. These could be supported by an occasional AZRI newsletter. In addition, linkages between PSRIs, government departments, agri-business, trade associations, and Chambers of Commerce should be established. This could include establishment of a committee that would meet once or twice a year. Close contact should be maintained with the newly established Agri-business Cell located in the Ministry of Food, Agriculture and Cooperatives in Islamabad.

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

(The 1986, 1987, 1988 and 1989 MART/AZR Annual Reports are published as ICARDA Reports Nos ICARDA-110, ICARDA-127, ICARDA-138 and ICARDA-158). The 1990 MART/AZR is published as a separate report obtainable from the ICARDA office in Quetta.

Papers in Refereed Journals

Atiq-ur-Rehman, S. Rafique, A. Ali and M. Munir. 1991. Nutritive evaluation of fourwing saltbush in growth and digestibility trials with Harnai lambs in highland Balochistan. Asian-Australasian Journal of Animal Science 3: 299-303.

Keatinge, J.D.H., A. Ali, B. Roidar Khan and S. Ahmad. 1991. Germplasm evaluation of annual sown forages under environmental conditions marginal for crop growth in the highlands of West Asia. Journal of Agronomy and Crop Science 166: 48-57.

Keatinge, D.J.H., A. Rodríguez, G. Farid Sabir, A. Afzal and N.A. Shah. Camels in the farming systems of the arid highlands of Western Pakistan: is management research a worthwhile investment? Journal of Arid Environments. In press.

Nagy, J.G., G.F. Sabir and J.M. Stubbs. 1991. Sheep and goat production in upland Baluchistan, Pakistan. Small Ruminants Research 4: 210-233.

Rafique, S., M. Munir, M.I. Sultani and A. Rehman. 1991. Effect of winter supplementation on the performance of Balochi ewes grazing native rangelands in highland Balochistan. Asian-Australasian Journal of Animal Science 4: 333-339.

Posters, Workshop and Conference Abstracts and Papers

Mahmood, K., and A. Rodríguez. 1991. The Marketing of live small ruminants and meat in highland Balochistan. Selected poster paper presented at the 21st International Conference of Agricultural Economists, Tokyo, Japan, August 22-29, 1991.

Mustafa, U. and K.N. Babar. 1991. Stochastic analysis of cereal crops grown under water-harvesting techniques in highland Balochistan. Dryland Resource Management Project Workshop, Amman, Jordan. November 11-14, 1991.

MART/AZR Research Reports

Arid Zone Research Institute and International Center for Agricultural Research in the Dry Areas. 1991. High elevation research in Pakistan, the MART/AZR Project Annual Report. MART/AZR Research Report No. 65, ICARDA Quetta.

Sabir, G. Farid, A. 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.

Sarfraz, A., A. Rodríguez, G. Farid Sabir, B.R. Khan, and M. Panah. 1991. Economic losses of wheat crops infested with yellow rust in highland Balochistan; survey results. MART/AZR Research Report No. 67, ICARDA, Quetta.

Asghar Ali, Sarfraz Ahmad, B. Roidar Khan, and J.D.H. Keatinge, 1991. Selection of vetch genotypes under rainfed conditions in highland Balochistan. MART/AZR Research Report No. 68, ICARDA, Quetta.

Sarfraz Ahmad, B. Roidar Khan, Asghar Ali, J.D.H. Keatinge and Irshad Begum, 1991. Selection of bread wheat genotypes for spring sowing in the arid highlands of Balochistan. MART/AZR Research Report No. 69, ICARDA, Quetta.

Khan, B.R., E.F. Thomson, A.Y. Allan and A. Rodriguez, 1991. AZRI research plans for 1991/92. MART/AZR Research Report No.70, ICARDA, Quetta.

Mahmood, K., and A. Rodríguez. 1991. Marketing and processing of small ruminants in highland Balochistan. MART/AZR Research Report No. 71, ICARDA, Quetta.

Chaudhry, M.A. 1991. Strengthening linkages between research, agribusiness and farmers. MART/AZR Research Report No. 72, ICARDA, Quetta.

Workshop Proceedings

AZRI (Arid Zone Research Institute). 1991. Range/Livestock Research: Proceedings of a Seminar, held December 21-23, 1988. Arid Zone Research Institute, Quetta.

Theses

Anwar Khan. 1991. Evaluation of cytoplasmic male sterile hybrid barley in hill plots. M.S. Thesis. Montana State University, Bozeman, Montana.

Mustafa, U. 1991. Economic impact of land degradation (salt affected and waterlogged soils) on rice production in Pakistan's Punjab. Ph.D. Thesis, Department of Agricultural Economics, University of the Philippines, Los Banos.

Zahid, A.Q. 1991. Water-harvesting from compacted soil surfaces to improve the productivity of rainfed agriculture. M.S. Thesis, Department of Agriculture and Irrigation Engineering, Utah State University, Logan, Utah.

Newsletter

AZRI NEWS. Issue Number 1: July - September 1991.
Issue Number 2: October - December 1991.

Annex 2. AZRI Headquarters Scientific and ICARDA MART/AZR Staff (on 31.12.91)

AZRI Staff

Director AZRI	Bakht Roidar Khan (PSO[1], PhD)
Agronomy/water harvesting	K.N. Babar (SSO[2], Deputy Director) Sher Mehmood (SO[3]) Muhammad Islam (SO) Mohammed Aslam (SO) M. Arshad Ali (SO, LTT[4]) Zahid Ali Qureshi (SO, LTT) Ahmad Samiullah (SO)
Germplasm Group	M. Anwar Khan (SO) Safraz Ahmed (SO) Irshad Begum (SO) Asghar Ali (SO, LTT) S.A. Jaleel (ASO[5])
Range Group	A. Wahid Jasra (SSO, PhD) Javed Afzal (SO, ad-hoc appointee) Abid Hussan (SO, ad-hoc appointee)
Livestock Group	Shahid Rafique (SSO, PhD) Muhammad Munir (SO) Atiq-ur-Rehman (SO, LTT) K. Nasir Mahmood (SO, LTT)
Economics Group	Usman Mustafa (SO, PhD) Khalid Mahmood (SO, LTT) Muhammed Afzal (ASO) Mohammad Jamil (SO, ad-hoc appointee) Imran Ali (MART short-term consultant) Nisar Ali Shah (grade 11)
Extension Group	M. Bilal Ahmad Chowdry (SO)

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

ICARDA MART/AZR Staff

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