THE MART/AZR PROJECT

HIGH ELEVATION RESEARCH IN PAKISTAN

Pakistan Agricultural Research Council

ARID ZONE RESEARCH INSTITUTE

Brewery Road, Quetta, Pakistan.

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THE MART/AZR PROJECT

ANNUAL REPORT FOR 1987

HIGH ELEVATION RESEARCH

AT THE

ARID ZONE RESEARCH INSTITUTE

QUETTA, PAKISTAN

MART / AZR PROJECT RESEARCH REPORTS

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

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

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

The principal objective of the MART/AZR Project is the Institutional support and development of AZRI in the period 1985-1989. This series of research reports outlines the joint research findings of the MART/AZR project and AZRI. They will encompass a broad range of subjects within the sphere of dryland agricultural research and are aimed at researchers, extension workers and agricultural policy-makers concerned with the development of the resource-poor, arid areas of West Asia and the Middle East.

Libraries, individuals and institutions may obtain single copies of this research report series free of charge and may request their names be placed on a mailing list for periodic notifications of published papers by writing to the MART/AZR project office, P.O. Box 362, Quetta, Pakistan.

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LIST OF COMMON ABBREVIATIONS

ARI	Agricultural Research Institute (Government of Baluchistan)
AZRI	Arid Zone Research Institute (PARC)
CIMMYT	International Wheat and Maize Research Institute
CSU	Colorado State University
FAO	Food & Agriculture Organization of the United Nations
FRMP	Farm Resource Management Program (ICARDA)
GOP	Government of Pakistan
MART	Management of Agric. Research & Technology Project
MART/AZR	MART Project Arid Zone Research Component
MSTAT	University of Michigan Statistical Package
PARC	Pakistan Agricultural Research Council
UNESCO	United Nations Educational Scientific and Cultural Organization
USAID	United States Agency for International Development

THE MART/AZR PROJECT - HIGH ELEVATION RESEARCH

ANNUAL REPORT 1987

INTRODUCTION

The Management of Agricultural Research and Technology Project - Arid Zone Research Component (MART/AZR) was initiated at the Pakistan Agricultural Research Council's (PARC) Arid Zone Research Institute (AZRI) in August 1985 through the financial sponsorship of USAID. ICARDA and Colorado State University are the contractors responsible for the technical implementation of the project. The principal objectives of the project are to provide support for the institutional development of AZRI and its staff; and the initiation of a research program in dryland agriculture, including livestock and rangeland management.

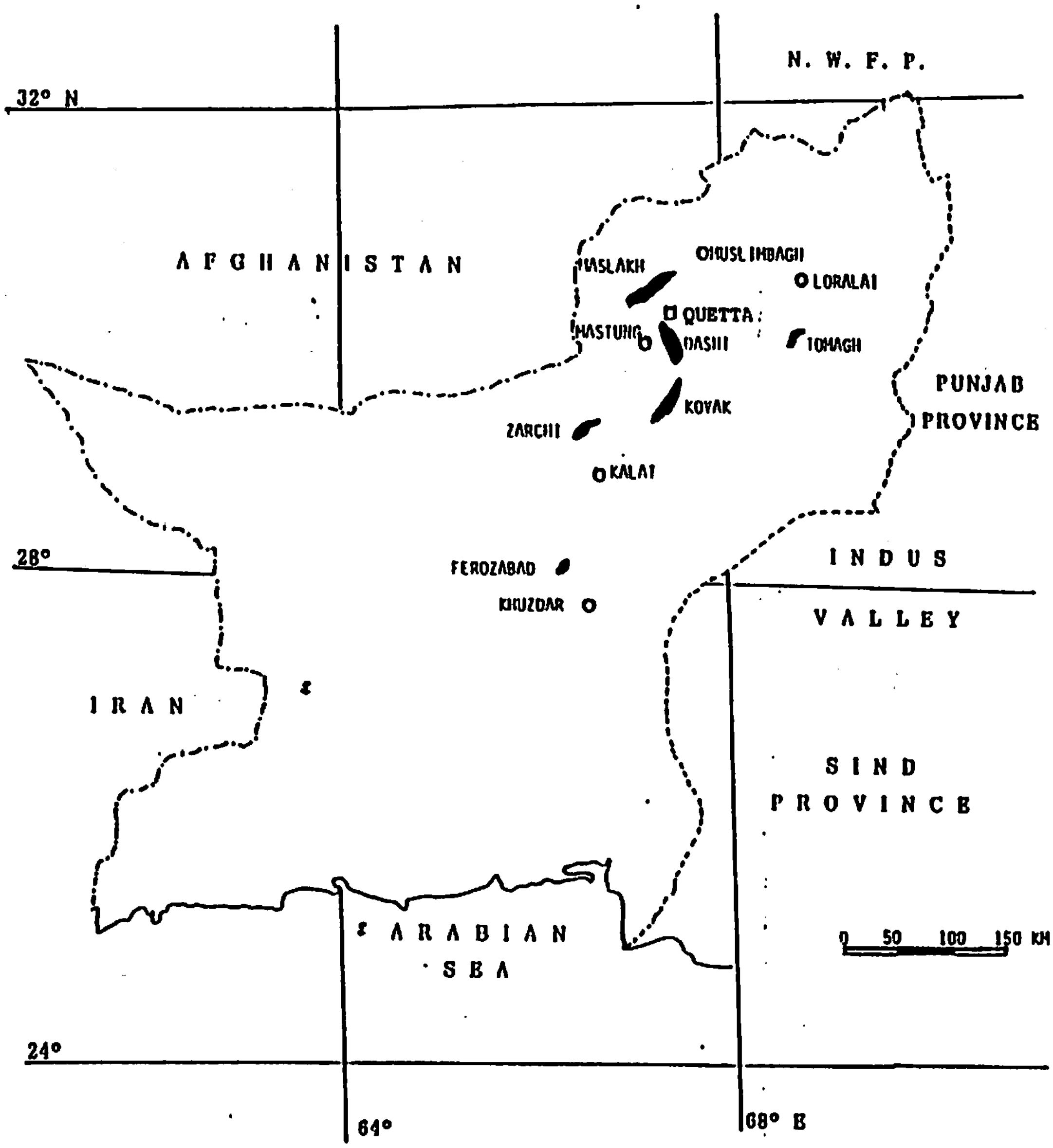
At present, the project is at the midpoint of the current phase of funding which will end in mid 1989. In the previous annual report for 1986 (ICARDA, 1987) the establishment year of the project was described in brief. In this report for 1987, technical results from the 1986-87 season are presented along with additional results from the 1985-86 season where these have not previously been reported.

The midpoint of the project is notable for the retirement of Dr. Sardar Riaz A. Khan - the Director of AZRI who has been associated with the project from its early inception. He will be succeeded by Dr. Bakht Roidar Khan, who has been the leader of the germplasm evaluation group at AZRI, since the beginning of the project.

The research program at AZRI has been developed in association with PARC, ICARDA headquarters, Colorado State University and provincial agricultural agencies of the Government of Baluchistan. A joint planning meeting to formulate research policies for the 1987-88 season was held in June 1987. Upland Baluchistan is the principal area of geographic emphasis for the project (Figure 1).

The research program has been designed along farming systems lines and is by nature highly integrated among disciplines. Five principal research groups were created, and have been operating at AZRI, during the lifetime of the project. Reporting of activities in this document will be by these research group subdivisions, for reasons of technical convenience. However, it should be noted that most research activities are joint group enterprises and that publications are more normally presented in a problem orientated cross-discipline basis. An example of this is the recent joint paper from the agronomy, germplasm, farming systems and extension groups describing the arable farming system of upland Baluchistan. This was presented at the ICARDA Symposium on High Elevation Agriculture at Ankara in July 1987 (Rees *et al.*, 1988). Training activities, which are normally arranged on a project-wide basis will be dealt with in a separate section.

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



TRAINING

The project offers four principal types of training support for the Arid Zone Research Institute staff and its collaborating provincial agricultural agencies.

A. On-the-job training

This is an ongoing process in the project. Five expatriate technical advisors, one per research group, work with their AZRI counterparts and junior staff in the implementation of the research program. This has proved to be a successful formula in upgrading AZRI's level of research competence. An example of this has been the introduction of the use of computers. In the last twelve months, AZRI's scientific officer-level staff have gone from a position of having no computer experience to an active and keen computer literacy. Our nine microcomputers are now in continuous operation during working hours.

B. Short-term training and local workshops

In the past twelve months the project has organized six workshops on the following topics: Introduction to the use of the IBM AT microcomputer; Use and abuse of analysis of variance; The use of the MSTAT statistical package; Techniques in range and livestock management research; Production techniques in the use of video cameras in agricultural extension and the role of written materials in agricultural extension. We have, where possible, encouraged participation by cooperating provincial research agencies, other components of the MART project and ICARDA HQ personnel in these workshops. Our staff has also contributed to other workshops in Pakistan, particularly in support of other MART Project components.

In addition, we have had a series of in-house English Language Training Courses. These have been focused on improving TOEFL scores amongst AZRI's scientific officer level staff. This has resulted in a marked improvement in the number of scientific officers who have attained the transitional 470-530 scoring band in the TOEFL. This is one of the qualifications required if they are to be included in AZRI's long-term training talent pool. Other objectives of the English program at AZRI are improvement in writing and speaking as well as reading and listening comprehension.

C. Medium-term training

The project was successful this year in sending three members of the range-livestock management group to summer courses at Iowa and Arizona state universities in the USA.

D. Long-term training

Two AZRI staff members have taken up long term, higher degree training positions in the USA in the last twelve months. Their areas of specialization are animal husbandry (Oregon State) and cold tolerance barley breeding (Montana State). One additional trainee in animal nutrition has had his program upgraded from an MSc. to Ph.D. at Arizona State University.

SUMMARY OF RESEARCH RESULTS

A. FARMING SYSTEMS

1. Highlights of a formal survey conducted in five dryland farming areas of upland Baluchistan are as follows:

    a. Household size averaged 17 persons of whom 4 were active workers.

    b. The area of land cropped per year by each household was dependent on the amount of rainfall received in summer or early winter and the amount of income available to the farmer from the previous season. The total varied between 3-5 ha in Dasht and 7-19 ha in Khuzdar. Locations are shown in Figure 1.

c. Wheat was the predominant crop grown, with barley and lentil as secondary choices.

d. Farmers' perceptions of the physical environment indicated that four years in ten would be bad for crop growth and only three years in ten would be favorable.

e. In bad years farmers estimated that wheat yields would be as low as 0.3-0.1 t/ha of grain. Whereas in favorable years, grain yields could be close to 1 t/ha.

f. Off-farm income was a substantial component of farmers' livelihood and increased with the severity of crop growing conditions.

2. Results of an informal survey and evaluation of secondary sources of the production of small ruminants in Baluchistan highlighted the following points:

a. There are approximately 12 million small ruminants (sheep and goats combined) in Baluchistan, and they are grazed almost exclusively on natural rangelands.

b. The livestock sector of Baluchistan contributes approximately 25 percent of the gross agricultural product. About 80 percent of the population depends on livestock in whole or in part for their livelihood.

c. Ninety-three percent of the land area of Baluchistan is classified as rangeland and at least 60 % of this, more than 20 million ha, is actively used for grazing.

d. In the areas surveyed, Zarchi and Tomagh (see Figure 1) average flock sizes range from 60-150 head with approximately two-thirds of the animals being sheep.

e. Lambing percentages are low (75 %) and there is an acute feed shortage in the winter period.

f. Animal feed deficits are alleviated by the practice of transhumance.

g. Farmers often derive more than 50 % of their income from livestock husbandry.

B. AGRONOMY

1. Chemical and physical data for arable soils from upland Baluchistan are presented in the major agronomy section of this report, as are rainfall and temperature data for 1985/86 and 1986/87.

2. Exploratory agronomy trials were conducted in 1985/86, a low rainfall year, and 1986/87, a high rainfall year, on wheat, barley, lentil and forage legume production, on tillage, and on water harvesting.

3. In 1985/86 rainfall varied with site from 140 to 200 mm. No significant monsoon rains occurred; thus, although crops were planted in October, they did not emerge until February, missing the most severe cold stress period. In 1986/87 unusually heavy monsoon rains occurred permitting

autumn planting and emergence. Annual rainfall totals varied with location from 250 to 750 mm.

4. Treatment of the upper portion of gently sloping fields to compact the soil, reduce infiltration and increase runoff to the cropped areas, resulted in 1986/87 in slightly increased yields (not statistically significant) even though only half the plot area was cropped. Greater differences between treated and untreated areas would be anticipated in drier years. However, even in this "wet" year, net benefits were increased 50% from 892 to 1,334 Rs/ha.

5. In 1986/87 N fertilizer significantly increased wheat straw and grain yields. Only two out of eight trials showed any response to phosphate fertilizer, even though Olsen P values ranged from only 3 to 8 ppm. K fertilizer and weeding had no effect on wheat production. The PARC recommended wheat variety Zarghoon was seriously damaged by cold in 1986/87 and yielded much less than the local variety. Addition of N fertilizer to the local wheat variety in a "wet" year (1986/87) increased net benefits with an overall marginal rate of return of 42%.

6. Exotic barley varieties yielded more than the local variety fairly consistently in both 1985/86 and 1986/87. Addition of N and P fertilizer did not increase yields in 1985/86, but gave significant increases in straw and grain yield in 1986/87. However, in contrast to the results with wheat, the yield increases were not sufficient to cover the fertilizer costs (lower percentage increases and lower grain price for barley) and net benefits were decreased by fertilizer application.

7. Exotic lentil varieties (3) were badly damaged by cold stress, whereas the local variety was unaffected. The forage legume *Vicia villosa* ssp. *dasycarpa* produced outstanding herbage yields in 1986/87. Inoculation with N-fixing bacteria substantially increased yields at most sites, with corresponding increases in net benefits. *V. villosa* produced higher net benefits than lentils (assuming similar seed and straw prices).

8. Deep tillage increased yields in 1985/86 but not in 1986/87, when heavy rains after plowing removed any tillage effect on the soil.

9. Barley generally, but not always, yielded more than wheat. The comparisons are not clear-cut, but the prospect for marked improvements in productivity by increasing barley hectarage at the expense of wheat are not particularly promising. *V. villosa* and lentils produced less straw and seed than the cereals but could have a useful role in crop rotations.

C. GERMPLASM EVALUATION

1. The major screening influences on introduced germplasm in the 1986-87 season were: the sudden onset of freezing air temperatures in mid-December, the higher than average seasonal rainfall, and the complete absence of disease pressure.

2. A restricted number of annually sown forage legumes and lentils performed extremely well in relation to local checks when planted in winter. Notable were *Vicia villosa* ssp. *dasycarpa* # 683, and FLIP 84-17L.

3. Productivity of forage legumes and lentils was much reduced by spring planting, particularly seed yields. However, for the first time since lentil screening began at AZRI, substantial numbers of lines equaled or exceeded the performance of the local check landrace.

4. There was a large positive response to inoculation of legumes by *Rhizobia* sp. at two of the three test locations.

5. Autumn-planted barley nursery results indicated that the local check varieties, in the absence of disease pressure, was highly productive (9 t/ha dry matter of which 2.5 t/ha was grain at ARI Sariab). Some introduced lines showed promise but could not match this performance.

6. Spring sown barley showed considerable variation in productivity between sites, but there was considerable similarity of performance between lines and many did as well as the local check landrace.

7. In the breadwheat nurseries, there was a high degree of mortality with autumn sowing, but some lines showed good cold tolerance and yielded more than the local landrace. Durum wheats sustained heavy damage due to cold.

8. Productivity of durum wheat lines was reasonably encouraging in locations without substantial cold effects or when spring-planted.

9. Chickpea nurseries were almost entirely killed by cold.

D. RANGE/LIVESTOCK MANAGEMENT

1. Two range-livestock research stations, Zarchi and Tomagh, were established to provide rangelands and animals needed to conduct grazing and livestock management studies. Each facility has the necessary shelter, feed storage and water systems for year-round maintenance of up to 150 sheep or goats, plus housing for permanent staff. Fencing has been installed for livestock control and specific research purposes. Windbreaks and forage reserve plantations have been established to help ameliorate the harsh environments of these sites.

2. Studies have been started at Zarchi research station, in an Artemisia spp. dominated desert shrub range type, to compare a deferred rotation grazing system with continuous grazing, and vegetation responses to different seasons of use. Grazing studies to compare vegetation responses to sheep and goat utilization have been established at Zarchi and Tomagh research stations. The latter site is in a mixed shrubland-grassland range type.

3. Range plant adaptability trials were started in early spring 1987 with 14 commercial grass species imported from the USA. Several of the species have exhibited good potential for establishment and persistence, even under the rather severe drought conditions present during the seven months following planting.

4. Forage shrub nurseries have been established at AZRI (Quetta), Zarchi and Tomagh in which fourwing saltbush (Atriplex canescens) seedlings are produced. Field trials to establish forage reserves and to test the feasibility of introducing this shrub into existing range vegetation have been started. Plans are laid for the start

of farmer-managed trials with fourwing saltbush forage reserves in cooperation with the extension group at AZRI.

5. Animal nutrition studies have been conducted at AZRI and the field stations to compare livestock responses to different feeds and feeding regimes. An experiment has been started with 90 ewes at each of the two field stations to evaluate effects of nutritional status on the productivity of these ewes over an annual production cycle.

6. Physical facilities for the AZRI range herbarium are nearly complete and collection development is underway.

7. Cooperative research and development relationships have been established with the Provincial Government Departments most closely related to rangeland management and livestock production in Baluchistan.

8. Range livestock research proposals have been evaluated, and initial facilities started, to expand this work at the two AZRI substations at Umerkot (Sind Province) and Bahawalpur (Punjab Province).

E. AGRICULTURAL EXTENSION

1. Agricultural extension in the dryland cropping areas of Baluchistan is considered to be a formidable task in the light of the low density of population, the tribal nature of rural society, widespread transhumance, multiple spoken languages, illiteracy and poor communications infrastructure and a history of low investment in dryland agricultural research.

2. Farmer managed trials were undertaken in Kovak valley (Figure 1) as a test of appropriate extension methodologies in cooperation with the agronomy and farming systems groups at AZRI. In these trials the introduction of a new wheat variety for spring planting, particularly in the presence of additional phosphate fertilizer proved to be a largely profitable strategy amongst the test farmers. Farmers reactions to the new technological innovations were closely studied in a post trial evaluation survey.

3. An initial vaccination campaign for livestock in the Kovak valley proved to be a popular success with farmers, but its longterm benefits can only be observed over the next two years.

4. A survey focusing on communication patterns within and between villages, as well as on the access of farmers to mass media and extension services, is presently in progress in five diverse areas of upland Baluchistan.

5. Active cooperation with all provincial extension agencies in Baluchistan is being fostered.

FARMING SYSTEMS

INTRODUCTION

The activities of the farming systems/agricultural economics research group at AZRI over the period 1986-89 will consist of four major areas:

A. The description of current farming systems and the identification of technological constraints to production within those systems.

B. The evaluation of the economic feasibility and risk considerations of new innovations to farming systems.

C. Investigation of the level of resource fit or compatibility with on-farm resources of new technological innovations to farming systems.

D. Analysis of intra-household and inter-household dynamics and socio-cultural acceptance of new technological innovations.

In the 1986-87 season efforts have been concentrated in the areas of farming systems description and economic evaluation. It should be noted that most of the research group's activities are performed in cooperation with AZRI's agronomy, extension and range/livestock groups and results should not be considered in isolation. Initial economic evaluation of technical innovations are given in the agronomy and extension sections which are presented later in this report.

RESULTS

Farmer Perspectives and Practices in Dryland Arable Systems.

Tables 1, 2 and 3 present the results of a formal survey of farming practices conducted in June 1986 in the Dasht, Mastung, Kalat and Khuzdar areas of Baluchistan (Figure 1). Table 1 shows some of the characteristics of the dryland arable farming system of upland Baluchistan.

Table 1. Characteristics of Baluchistan's dryland farming systems.

	Locations				
	Dasht	Mastung	Kalat	Khuzdar	All
Members/household	14.0	20.5	17.6	16.2	17.0
Active workers/ household	3.9	4.2	3.5	3.4	3.7
% cropped of total owned land	71%	75%	48%	40%	47%
Crop land type					
Rainfed	88%	69%	72%	46%	68%
Streamfed	12%	31%	28%	54%	32%
Streamflow occurrence in years out of 10	3	3	3	3	3
Power Source					
Plowing (%)					
Animal only	20%	15%	65%	50%	
Tractor only	15%	25%	0	0	
Both methods	65%	60%	35%	50%	
Planting (%)					
Animal only	100%	100%	100%	100%	
Harvest (%)					
Hand only	100%	100%	100%	100%	
Threshing (%)					
Hand only	35%	11%	5%	2%	
Animal only	45%	57%	87%	83%	
Both methods	17%	24%	8%	12%	
Tractor only	3%	8%	0	3%	
Plowing					
Before rains	0	20%	0	0	
After rains	100%	80%	100%	100%	
Plow field once	54%	40%	42%	24%	
Plow field twice	46%	60%	58%	76%	
Planting Method					
Wooden drill	20%	30%	62%	61%	
Broadcast	15%	40%	28%	16%	
Both methods	65%	30%	10%	23%	

Table 2. Dryland farmer's perceptions of area planted, yield and off-farm income by type of year in Baluchistan.

	Locations											
	Dasht[1]			Mastung			Kalat			Khuzdar		
	G	N	P	G	N	P	G	N	P	G	N	P
Good, Normal or Poor Agr. years in ten.	3	4	4	2	4	4	2	3	5	2	5	3
Total cropped land (ha.)	5	5	3	13	10	6	15	12	5	19	18	7
Rainfed land planted (%)												
Wheat	60	60	60	75	70	70	80	80	67	75	70	60
Barley	25	25	20	25	30	30	20	20	33	15	20	40
Lentils	15	15	20	0	0	0	0	0	0	10	10	0
Streamfed land planted (%)												
Wheat	75	75	100	80	70	70	85	85	85	70	75	80
Barley	0	0	0	20	30	30	15	15	15	20	20	20
Lentils*	25	25	0	0	0	0	0	0	0	10	5	0
Farmer's yield expectations												
Rainfed Land (t/ha)												
Wheat	.4	.3	.1	.4	.3	.1	.4	.3	.1	.5	.3	.2
Barley	.3	.3	-	.3	.2	-	.3	.3	-	.3	.3	-
Lentil	-	-	-	-	-	-	-	-	-	-	-	-
Streamfed (t/ha)												
Wheat	.8	.6	.3	.7	.6	.3	.9	.6	.3	.9	.7	.4
Barley	.5	.4	.2	.5	.4	.2	.5	.4	.2	.6	.4	.2
Lentil	.4	.3	-	-	-	-	-	-	-	.5	.3	-
Off-Farm Income (%)	10	18	33	15	38	65	13	34	64	11	28	56

[1]G, N, and P represent good, normal, and poor agricultural years as perceived by the farmers.
*Cumin (*Cuminum cyminum*) is also a minor crop in some areas.

Forty to seventy-five percent of the arable land controlled by the farmer is cropped. The ratio of streamfed to rainfed land varies with district (and the potential for this form of water harvesting) from 12 to 54%. However, the farmers indicate that streamflow onto their land occurs only three years in ten, leaving them to rely on rainfall alone for seven years out of ten.

Tractors, as a power source for plowing, are used at all locations. The main implement used for plowing with a tractor is the spring-tine cultivator, none of the respondents used a moldboard plow. A small proportion of farmers in Dasht and Mastung valleys (15 and 25% respectively) use only tractors for plowing. These two locations are influenced by their close proximity to the major city of Quetta where tractor availability is greater. A much larger proportion (38% overall) use only animal draft as a power source for plowing. Planting and harvesting at all locations is done solely by non-mechanical means. Threshing is predominantly with animals and rarely with a tractor or threshing machine.

Almost all respondents plowed after rains, except in Mastung where 20% said they plowed prior to the first major rain (however, AZRI field staff have observed some farmers plowing prior to rain in other areas). An average of 60% plow twice, noticeably this percentage is higher in the Khuzdar location where soils are much heavier. The broadcasting method of seeding constitutes a major proportion of the land being sown in February when the seed is broadcast onto moist soil immediately following rain.

With the exception of tractors, modern inputs are not used. Fifty to 95 percent of farmers across all locations said that they were prepared to rent and would like to use a tractor for plowing. All respondents at all locations said that they did not use improved varieties, fertilizers, pesticides or herbicides on their dryland crops. Farmers did recognize that there were yield losses because of weeds and pests/diseases. The perception of farmers over all locations was that they lost between 10% to

18%, 7% to 15% and 20% to 35% to weeds in wheat, barley and lentils respectively. Most farmers said that they hand weed but observations by field staff suggest that little weeding is done. Farmers said that the loss due to pests/diseases was 11% to 21%, 14% to 20%, and 16% (Dasht only) in wheat, barley and lentils respectively.

Table 2 presents farmers' perceptions of the areas planted and yields by type of year. Farmers were asked to give their perception of how many years in ten would be categorized as a "good", "normal" or "poor" agricultural crop year based on grain and fodder yield relative to rainfall level and distribution. Over all locations, 3 to 5 years out of ten were categorized as "poor" agricultural years. This indicates the high degree of production risk involved within the dryland farming system of upland Baluchistan and is corroborated by rainfall data (Rees, et al., 1988). The present farming systems practices of dryland Baluchistan have evolved with this risk in mind and indicates why available modern inputs such as fertilizers have not been adopted by farmers to date.

Farmers respond to the type of year by altering the number of hectares planted to cereals and lentils. Farmers make their planting decisions based on the amount and distribution of the summer and autumn rains. As indicated in Table 2, total hectarage planted is decreased in the poorer agricultural years. This is true for both rainfed and streamfed land. Although farmers decrease the amount of hectares planted in poorer years, the proportion of hectares planted to wheat, and barley remains fairly constant across "good", "normal" and "poor" years. A possible exception is the substitution of barley for wheat on rainfed land in Khuzdar and a shift from lentils to wheat on streamfed land in Dasht. Farmers indicated that lentil planting increased slightly on rainfed land in Dasht (data suspect) but that lentils were not grown in "poor" years in Khuzdar or on streamfed land in Dasht.

Table 2 also presents farmers perceptions of the yield that they receive in the three types of agricultural years. Streamfed land produces about double the yield of rainfed land. Very little crop is produced in the "poor" agricultural years and is thus significant because as previously indicated, a "poor" year occurs 3 to 5 years out of 10 over all locations. It is interesting to note that the farmers consider barley to be a lower yielding crop than wheat. Field observations suggest that this is because they plant only the poorer land to barley, reflecting a greater interest in wheat. Farmers indicate that they do augment their farm income with income from outside sources. Their participation in outside sources of income increases in poorer years as shown in Table 2.

Table 3 shows farmer's estimates of the percentage of their animals' nutrition supplied by fodder from their arable activities. Camels, the main source of animal draft power, obtain about 44% of their feed requirements from fodder averaged over the whole year; sheep and goats obtain only about 16%. No attempt was made to determine the nature of the fodder - observations indicate that this is largely wheat straw, with occasional concentrate supplements.

Table 3. Source of animal feed for two locations in Baluchistan.

	Location							
	Khuzdar				Kalat			
Seasons[1]	S	SM	A	W	S	SM	A	W
	%							
Sheep and Goats								
Grazing	89	92	86	63	80	98	93	56
Fodder	11	8	18	37	20	2	7	44
Camels								
Grazing	66	53	58	0	72	59	75	87
Fodder	34	47	42	100	28	47	25	13

1 Seasons S = Spring (March-April), SM = Summer (May-August), A = Autumn (September-November) and W = Winter (December-February).

Small Ruminant Production Systems on Natural Rangelands

While the land area of Baluchistan is vast (34.7 million ha), only about 4% is cultivable (1.47 million ha.) of which only 0.68 million ha. are irrigated. Non-cultivable land is made up of desert shrub, shrub steppe and semi-arid forest rangelands. Ninety-three percent is classified as rangeland of which 20.9 million ha or 60% of the total area is used actively for grazing (Table 4). The main animal producing regions are in the central and northeastern areas of Baluchistan (Buzdar and Jameson, 1984).

The livestock sector of Baluchistan contributes an estimated 25% (1982-83 est.) of the Gross Agricultural Product (GAP). This is a decrease from the estimated 41% GAP that the livestock sector contributed in 1973-74 although the Gross Livestock Product has increased 6 times between 1973-74 and 1982-83 (Table 5).

Sheep and goats are the major form of livestock and represent 48.3% and 42.3% of all domestic animals (excluding poultry) in Baluchistan (Table 6). About 80% of the population depends on livestock in whole or in part for their livelihood (Government of Pakistan). Sheep and goat numbers have increased substantially from 1955 putting more pressure on the rangelands (Table 6).

Table 4. Baluchistan agricultural land and labour resources.

Population (1981)		4.3 Million
Labour Force in Agriculture		67%
Average Rainfall		100-400 mm
Land Use	Million ha.	Percent
Total Land Area	34.72	
Cultivable area	1.47	4
Irrigated Area	0.68	
Forests	1.07	3
Rangelands	32.3	93
Unproductive	9.8	(28)
Poor Grazing	11.7	(34)
Good Grazing	9.2	(26)
Undergrazed	1.6	(5)

Source: Development Statistics of Baluchistan, 1983-84, and FAO, Report of the Assistance to Rangeland and Livestock Development Survey in Baluchistan, FAO Technical Cooperation Program, FAO, Pakistan.

The major source of feed for most of these animals in Baluchistan is rangeland. It is estimated that 90 to 95 percent of the feed for sheep, goats, camels, and donkeys comes from rangelands (See FAO Report mentioned in Table 4).

An informal survey was conducted at Zarchi (Kalat District) south of Quetta and at Tomagh (Loralai District) northeast of Quetta (Figure 1). At Zarchi, the altitude is about 1800 m, average rainfall is between 170 to 200 mm of which 90% falls in the winter-spring months. The range vegetation is an *Artemisia* shrub steppe. Sheep and goats are mainly grazed on the range in the spring-summer-autumn period. Migration of people and their flocks to the Indus valley is prominent in the winter months. When flock owners were asked if they would rather not migrate in the winter, if they had sufficient feed for their flocks, the answer was, "Yes".

Table 5. Baluchistan Gross Agricultural Product.

	1973-74		1982-83	
	(Rs.mil)	(%)	(Rs. mil)	(%)
Crops	343.3	59	4,584	75
Livestock	242.1	41	1,515	25
Total	585.1		6,099	

Source: FAO, Report of the Assistance to Rangeland and Livestock Development Survey in Baluchistan, TCP/PAK/0107, FAO Technical Cooperation Program, FAO, Pakistan.

Some of the major production constraints and priority problems facing the range-livestock sector appear to be as follows: Low and erratic inter- and intra-year rainfall, low soil fertility, low rangeland productivity, feed shortages in the winter months, land constraints to grow additional forage, no overall management of common grazing land which has led to overgrazing and deforestation, vegetation slow to grow in spring (Tomagh area), livestock diseases - little use of veterinary services.

Farmers and herders also make comments on constraints and priority problems, such as insufficient health, education, credit and extension facilities. Comments are also made on the lack of electrical, transport and irrigation infrastructure. Farmers perceive that the biggest constraint to increasing their well-being is the lack of natural (kareze) irrigation or tube wells.

Table 6. Baluchistan livestock population, 1955 to 1986.

Livestock Type	1955	1960	1972	1976	1986	% share[1] (1986)
			'000s			
Sheep	1157	2564	3859	5075	6820	48.3
Goats	702	1596	3238	4441	5969	42.3
Cattle	295	643	482	684	755	5.4
Buffaloes	26	26	22	33	37	0.3
Camels	70	86	185	212	234	1.6
Asses	61	99	171	244	269	1.9
Horses & Mules	16	11	19	23	24	0.2
Poultry	283	454	1183	1958	7921	-

Source: GOP, 1985 for 1955 to 1976 and Baluchistan Livestock Department for 1986.

[1] Excludes poultry.

At Tomagh, the altitude varies from about 1700 m on the lower range to 1800 m on the upper range of the mountain sides. Yearly precipitation averages 300 mm with 60% falling in the Fall-Winter months and 40% in the Spring-Summer months. The vegetation is a grassland type on the lower range and mixed shrub-grassland on the higher ranges. *Chrysopogon* and grassland on the higher ranges. Chrysopogon and Cymbopogon sp. grasses are the dominant vegetation types. Sheep and goats are grazed yearlong. Local migration of flocks in the summer months, to better pastures at the nearby upper rangeland, is common.

There is a feed shortage in the winter months at both locations. Fodder is in short supply and farmers say that they cannot afford to buy fodder. Thus few farmers use supplementary feed. Disease and most animal deaths coincide with the winter feed shortage period. Fodder, mainly lucerne, is grown in the Tomagh area within the orchards. Farmers at Tomagh say that they would like to grow more forage for fodder but that there is a land constraint. Water shortage and quality problems are also reported for Zarchi. Veterinary services are used very little. The farmers said that the cost is too high.

Most flocks are herded by family members with some owners employing full-time herders. Animals are grazed within three to five kilometers from water points. The grazing areas are managed by the herders by choosing the best spots first and grazing different parts of the range at the start of each day. There is no overall rangeland management practiced by the herders on communal land and there is evidence of overgrazing and deforestation.

The agriculture at Zarchi is characterized by crops and livestock while the farming system at Tomagh includes orchards, crops and livestock. The proportion of income from livestock activities are about 70-80% at Zarchi and 40-50% at Tomagh. No effort is made to control breeding to ensure that the animals are ready for sale at peak price periods. The disposition of sheep and goats for consumption and marketing is made on an as-needed basis, when food and cash are required. Livestock are sold directly to the nearest market or to middlemen who travel to the farm. Transport to market and the selling of livestock at a low price in an emergency were priority marketing problems. Farmers also seem uncertain that they actually receive a fair price.

Table 7 presents some of the basic information that was gathered from the informal survey.

Table 7. Selected Informal Survey Information.[1]

	Location	
	Zarchi (Kalat District)	Tomagh (Loralai District)
Enterprise type	Crop/Livestock	Orchard/Crop/ Livestock
Livestock breed		
Sheep	Baluchi	Harnai
Goats	Local	Local
Sheep/goat ratio	75/25	60/40
Herd size	60-150	60-100
Breeding male/ female ratio	1:50	1:40
Lambing rate	65-75%	60-70%
Lambing month	Mid Jan. to Mar.	March
Breeding age	18 months	18 months
Shearing		
Sheep	April & Autumn	April & Autumn
Goats	April	April
Castration	Yes	Yes
Feed shortage period	Dec-Mar.	Nov-Mar.
Fodder types	Lucerne	Lucerne Cut grain
% farmers who use supp. feed	?	10%
Water shortage	In Summer	No
Water quality Problems	With water from pools in summer	Good quality water from steams
Waterings/ day	Twice in summer, once in winter	Same

Table 7 (continued)

	Location	
	Zarchi (Kalat District)	Tomagh (Loralai District)
Distance to water	3-5 km.	3-5 km.
Diseases[2]	Lung diseases Liverflukes	Lung diseases
Prevalent disease months	Nov.-Feb.	Nov.-Jan.
Abortions	?	5-10%
Use of Vet. services	No	No
Predators	Wolves	Wolves
Housing	Open in summer, closed shelters in winter	Same
Migration	Sibi, Kachhi, Jacobabad (Indus Valley) Nov.- Mar.	Local June-Aug.
Livestock income proportion	70-80%	40-50%
Marketing period	Consumption and marketing on an as-needed food and cash basis. Lambing & marketing not scheduled to meet peak price periods such as religious events. Livestock used as a store of wealth.	

[1] Informal interviews with 4 to 5 farmers at each location.
[2] Livestock diseases could not be properly defined because a veterinar did not accompany the team.

AGRONOMY

INTRODUCTION

The ICARDA Agronomy advisor arrived in Quetta in September 1985 and initiated a series of "diagnostic agronomy" trials in October 1985. It was apparent that very little information was available upon crop growth and performance in purely rainfed conditions in upland Baluchistan and so the trials were designed to provide a basic data base quantifying crop growth under "optimal" management in this environment, as well as responses to fertilizer, tillage etc. All trials were carried out on farmers' fields, but implemented by the Agronomy staff of AZRI.

Figure 1 shows the position of upland Baluchistan and of the major sites where this work was carried out. In 1985/86 trials were restricted to Quetta, Dasht and Mastung valleys, all in the altitude range 1600-1800 m, with annual "normal" rainfall of 200-250 mm. In 1986/87 trials were extended to Kovak valley (2000m altitude, 200-250 mm annual "normal" rainfall), and to Ferozabad, near Khuzdar (1200m altitude, 200-250 mm annual "normal" rainfall).

The category of "rainfed" arable land includes two types of land use: purely rainfed ("kushkaba" in local terminology); and streamfed from ephemeral streams ("sailaba"). This latter category is perceived by farmers to be much more productive when streamflow occurs, but as this is likely to occur only 3 years in 10 (Rees et al., 1988), it may not be very important. The trials in Dasht valley have attempted to quantify this by repeating trials on "kushkaba" and "sailaba" land where possible.

SOILS.

Table 8 summarizes chemical and physical characteristics of the soils on which the trials were carried out, and provides some initial data describing the arable soils of upland Baluchistan. In general, these valley soils (classified as alluvial yermosols in the FAO classification) are light to medium in texture, high in lime percentage, have high pHs, low to medium in available phosphate content and low to very low in organic matter and nitrogen. Hassan and Rizvi (1974) and Shaikh, Bangash and Rizvi (1974) provide similar data for irrigated arable soils of Baluchistan which show similar textures, but lower pHs, and higher organic matter, phosphate and total nitrogen. The Olsen P values presented here suggest that responses to phosphate fertilizer may be expected about 50% of the time, whilst the Kjeldahl total nitrogen suggests that responses to nitrogen fertilizer can be expected, provided that, in both cases, water is not too severely limiting. The soils have little structural stability and tend to form crusts following wetting. These crusts can be strong enough to drastically reduce emergence on the heavier textured soils (sandy clay loams) but usually not on the lighter soils (sandy loams).

Table 8. Summary of upland Baluchistan dryland arable soil chemical and physical characteristics, 0 - 30 cm depth. (Analyses carried out by the Soils Laboratory of FRMP ICARDA HQ in Syria).

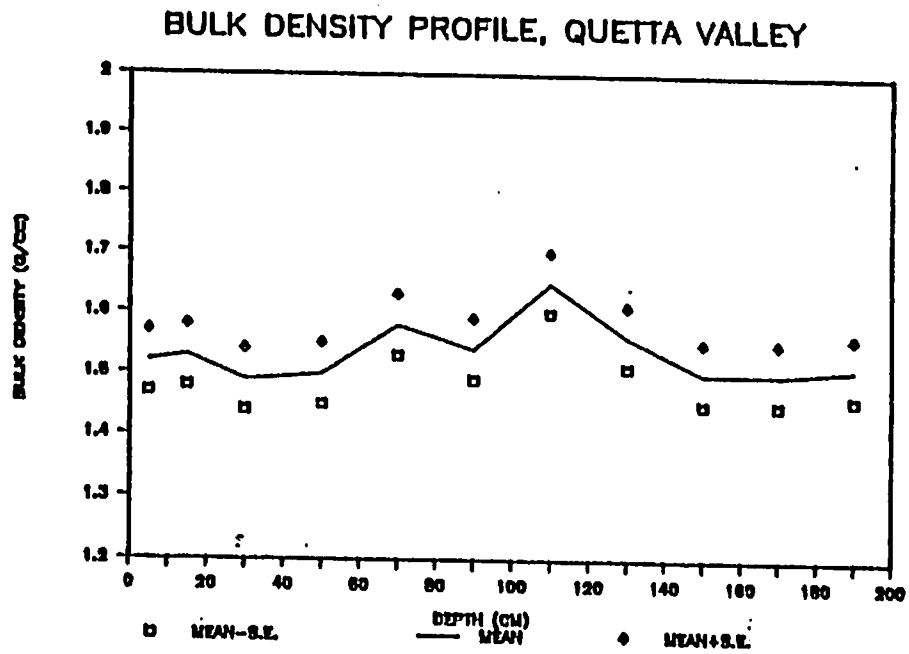
Location	Trial Year	pH (1:1)	Lime (%)	Olsen P (ppm)	O.M. (%)	Kjeld. N (ppm)	Clay (%)	Silt (%)	Sand (%)	Texture
Maslakh	85/86	8.8	19.1	4.4	0.4	320	15.6	39.4	42.9	SL[1]
Quetta	85/86	8.7	32.1	6.0	0.6	415	21.3	57.2	19.6	SL
Dasht	85/86	8.6	29.2	6.6	0.6	464	18.8	58.7	20.7	SL
Dasht K 1[2]	86/87	8.5	26.9	5.9	0.6	442	15.3	58.4	23.6	SL
Dasht K 2	86/87	8.4	21.9	6.6	0.7	595	30.0	59.2	9.7	SCL
Dasht S 1	86/87	8.4	24.2	8.3	0.7	486	11.8	64.8	21.5	SL
Dasht S 2	86/87	8.4	28.8	4.3	0.5	353	9.8	53.2	36.1	SL
Mastung	85/86	8.9	22.9	4.4	0.4	262	14.2	51.9	32.1	SL
Kovak	86/87	8.4	25.7	6.8	0.8	538	13.3	59.8	24.6	SL
Khuzdar	86/87	8.4	25.7	6.4	0.5	417	28.4	44.7	25.2	SCL

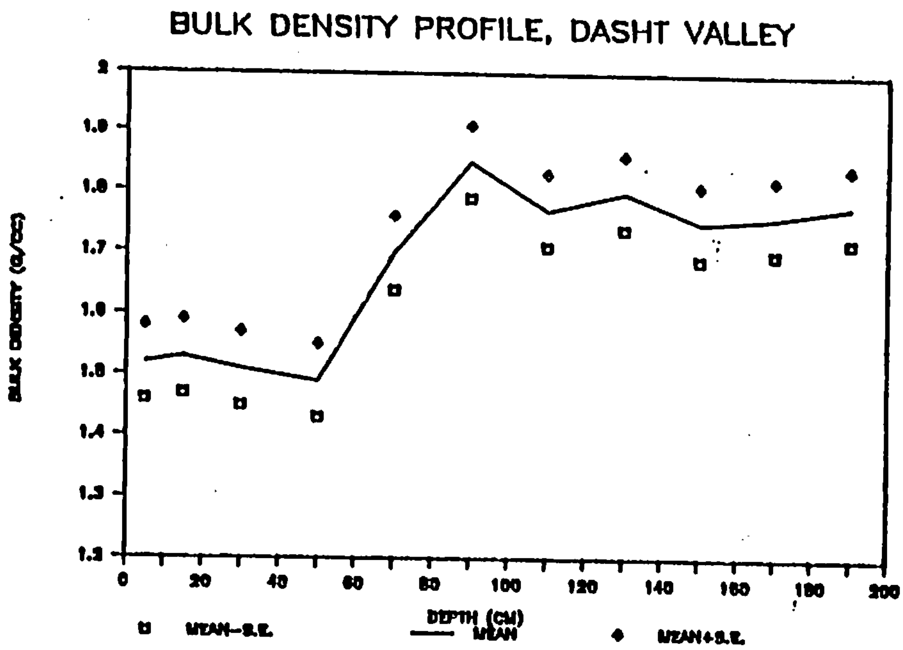
[1] SL - sandy loam; SCL -sandy clay loam.
[2] Dasht K, Dasht S - "kushkaba" and "sailaba" fields in Dasht.

Maslakh	: 30°20'N 66°40'E	Quetta	: 30°13'N 66°57'E
Dasht	: 29°58'N 66°52'E	Mastung	: 29°48'N 66°50'E
Kovak	: 29°28'N 66°47'E	Khuzdar	: 27°47'N 66°23'E

Bulk densities were determined in two fields in 1986 by taking precise volumetric cores from the side of pits dug to 2 m depth. Results are shown in Figure 2. In Dasht there was an apparent change in bulk density between 50 and 90 cm depth. The overall average bulk density, 1.6 g/cc, is high enough to present some impedance to rooting, whilst the even higher values below 80 cm in Dasht may present some serious barrier to rooting.

Figure 2. Bulk density profiles: (a) Dasht valley; (b) Quetta valley





THE WEATHER 1985/86 AND 1986/87.

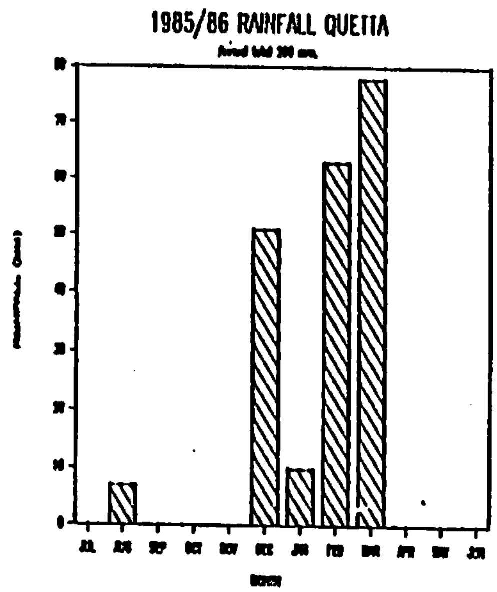
Figures 3 and 4 show the rainfall recorded at the various sites during 1985/86 and 1986/87. In 1985/86 there was a small monsoon (July-August) rain recorded in Quetta only, so that autumn-planting into moist soil was not possible. Many farmers planted their crops into dry soil at the end of October and this practice was followed for the trials reported here. However, the December rains occurred when temperatures were too low to allow germination (Figure 3) and emergence did not occur until temperatures started rising in February 1986. Dry planting results in very high probabilities of a crust forming above the emerging seedlings (depending upon precise weather conditions) as was observed in these trials, and on the heavier sandy clay loam soils it was necessary to break the crust manually above the emerging seedlings. Clearly a better practice would be to plant into moist soil in February. Many farmers of upland Baluchistan prefer to plant their crops in autumn, migrate to the warmer lowland areas for winter and return in late spring - for these farmers sowing into dry soil, although not technically advisable, is the only choice. Annual rainfall totals for Quetta, Dasht and Mastung were 206, 138 and 144 mm, respectively, compared to the long-term "normal" for Quetta of 240 mm (farmers in Dasht and Mastung classified the 1985/86 season as a "poor" season out of three categories: "good", "normal" and "poor").

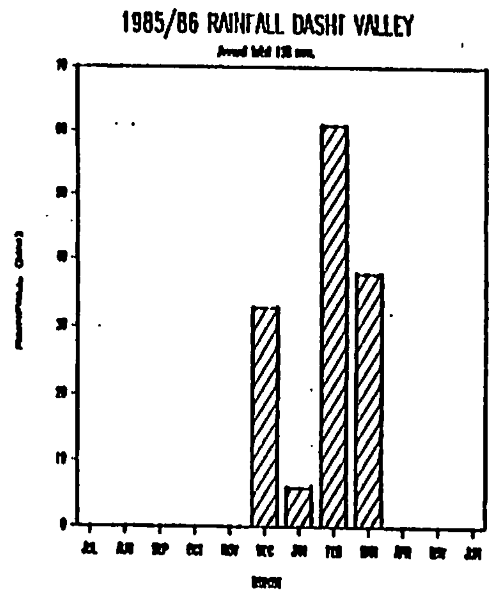
In 1986/87 rainfall was much higher and similar values were recorded in Quetta and Dasht. Large monsoon rains were recorded at all sites in August (380 mm in Ferozabad, Khuzdar), permitting planting in September/ October. Rainfall was subsequently poor in December and January, but good rains in February and March resulted in reasonable moisture availability during grain-filling. The unusually large rain in Ferozabad in May 1987 resulted in water-logging and some crop damage.

Table 9 summarizes measurements of soil water taken at planting in the two years. These varied from

38 to 75 mm in 1985/86 and from 58 to over 200 mm in 1986/87. As would be expected, in 1985/86 when there was no monsoon rains or streamflow, the "sailaba" fields did not have higher soil water contents than the "kushkaba" fields. In Kovak the monsoon rains were only 60 mm and streamflows only occurred on one side of the valley - not the side on which the Agronomy trials were situated - and soil water contents were correspondingly low. In Ferozabad, Khuzdar the 380 mm monsoon rains did not result in particularly high soil moisture storage, unless this was below 1m depth. One "sailaba" site in Dasht, at the bottom of a catchment of between 3 and 5 degrees slope, received large flood water inputs, resulting in a soil water content of over 200 mm to 1 m depth.

Figure 3. Monthly total rainfall, 1985/86





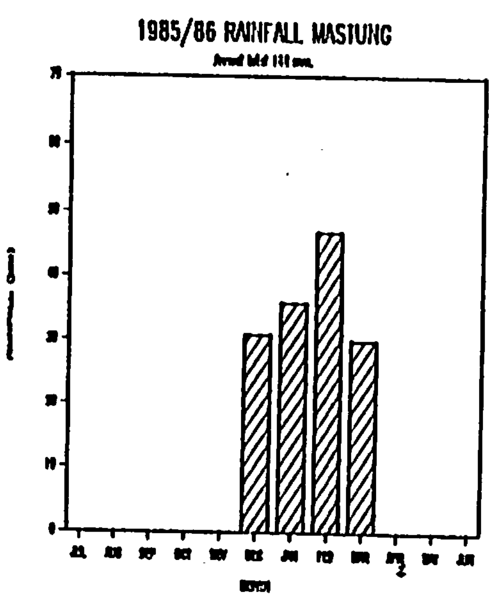


Figure 4. Monthly total rainfall, 1986/87

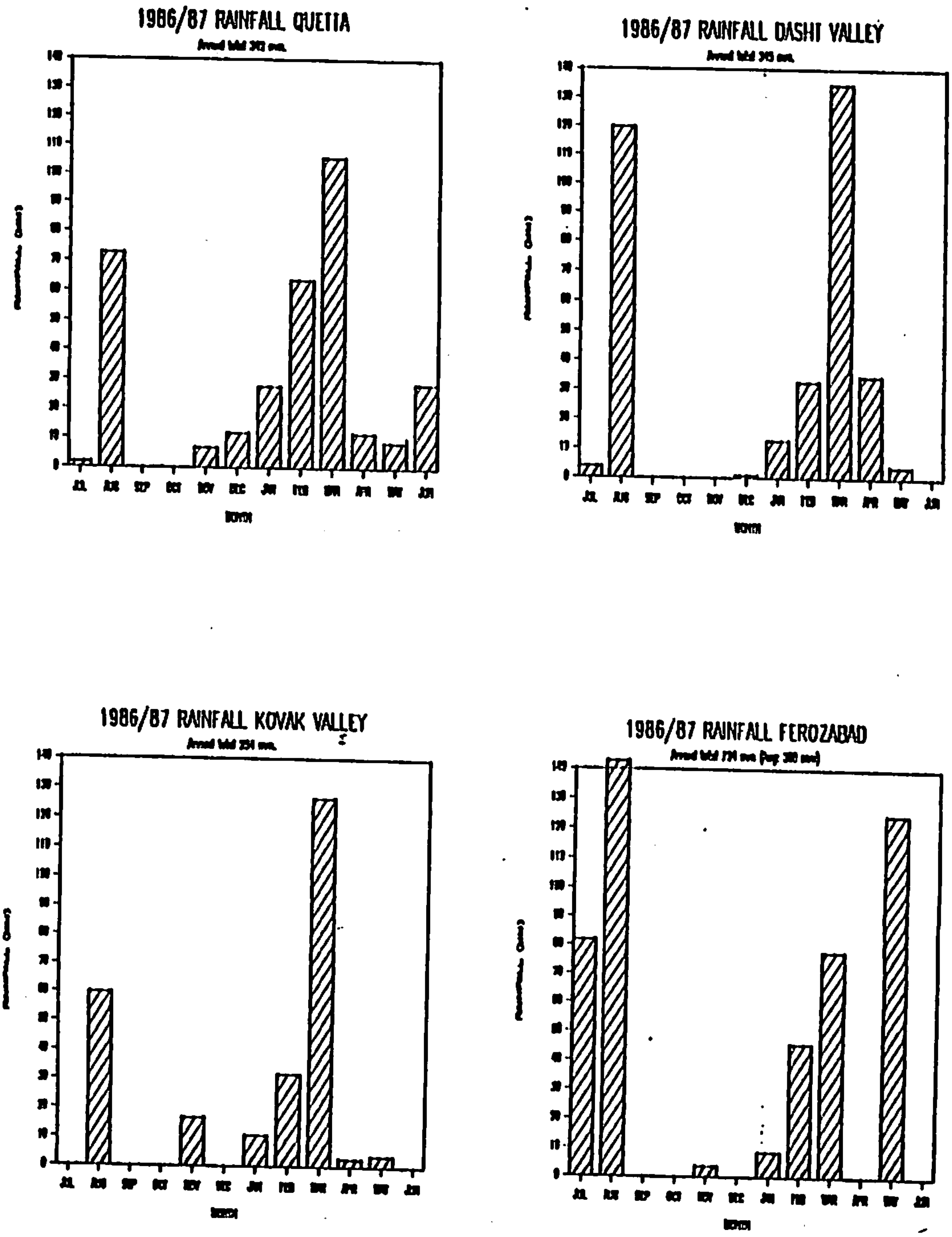


Table 9. Soil water to 1 m depth (mm) at planting of selected fields (assumes a common bulk density of 1.60 g/cc).

Field	1	2	3	4	5	6	7	Mean
1985/86								
Quetta								
kushkaba	75							75
sailaba	43							43
Dasht								
kushkaba	38	88						63
sailaba	50	42						46
Mastung								
kushkaba	59							59
1986/87								
Dasht								
kushkaba	105	111	88	135				110
sailaba	206	142	134	119	113			143
Kovak								
sailaba	64	62	60	64	59	58		61
Khuzdar								
sailaba	144	132	129	102	167	116	137	133

Figure 5 presents minimum and maximum temperatures recorded at the Arid Zone Research Institute, Quetta. (Attempts to obtain temperature records at each site by employing local farmers were not very successful.) Maximum temperatures varied from 39°C to 0°C in 1985/86, and from 39 to 6°C in 1986/87. Minimum temperatures varied from 24 to -10°C in 1985/86, and from 23 to -12°C in 1986/87. 1986/87 was slightly colder than 1985/86: averages from November to February were -1.4°C in 1985/86 and -1.8 in 1986/87; No. of frost days: 78 in 85/86 and 75 in

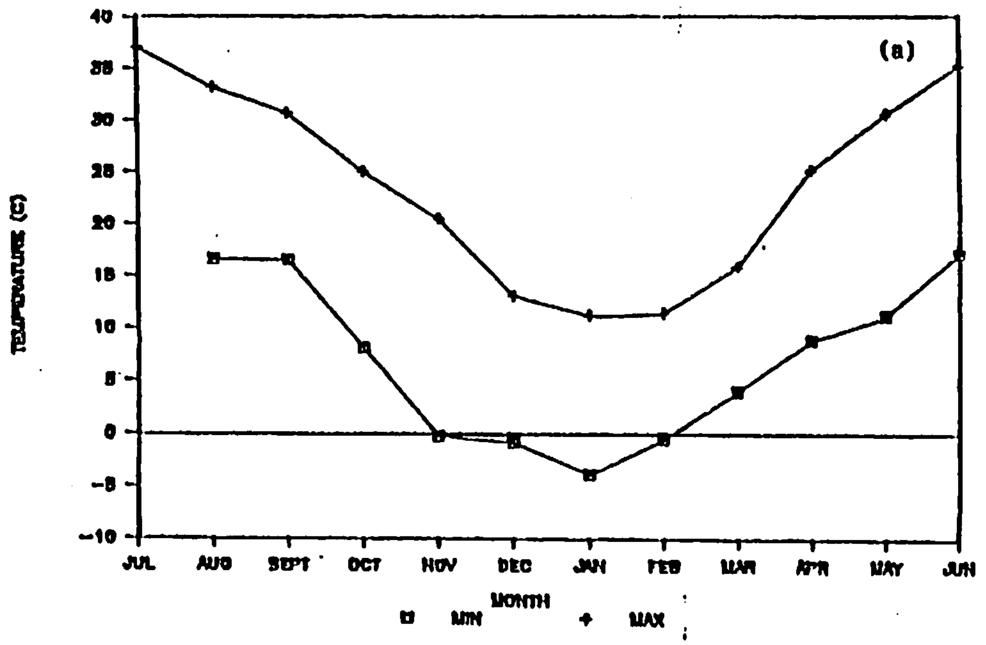
86/87; No. of days below -5 C: 23 in 85/86 and 31 in 86/87.

WATER HARVESTING TRIAL.

In 1985/86 it was observed that, even during the gentle winter rains, runoff within fields occurred, to be trapped by the earthbanks, or bunds, built by farmers around their fields. It was also observed that in many fields crop growth in the upper portions (typical slopes vary between 0.5 and 2 degrees) was patchy and poor. A technique of water harvesting was devised to reduce infiltration in the upper part of the field and so increase runoff onto the lower portion which would be cropped. The soil of the catchment area was simply plowed and then pulverized by dragging a heavy plank behind a tractor to destroy any soil structure and encourage crust-formation. After wetting of the soil by the first rains a compacted, crusted surface layer was formed. Three treatments were compared: control; 1:1 crop: catchment area; 2:1 crop:catchment area.

Figure 6 presents the grain and straw dry weights recorded at increasing distances from the bund for the three treatments. The decline in straw and grain yields with distance from the bund in the control plot is apparent. The higher grain and straw yields of the 1:1 treatment is also apparent. The 2:1 treatment did not perform as well as the 1:1 treatment. Table 10 summarizes the overall production in the three treatments. The 1:1 treatment produced higher grain yields (differences not statistically significant) and similar straw yields to the control, despite only half the total area being cropped. This result is encouraging as much greater differences can be expected in drier years.

Figure 5. Mean monthly maximum & minimum air temperatures, recorded at AZRI, (a) 1985/86; (b) 1986/87



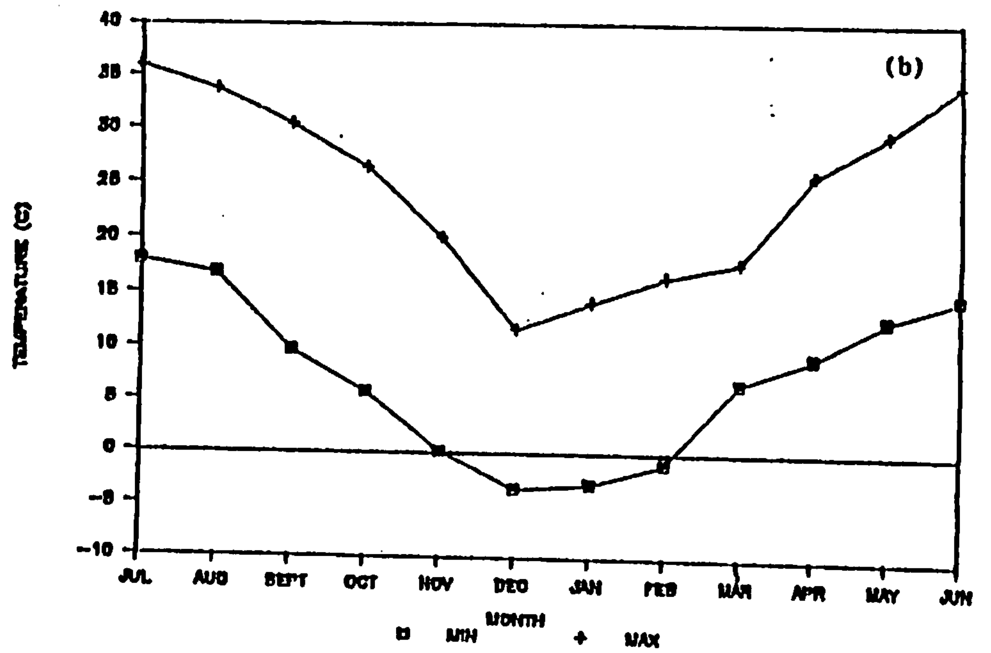
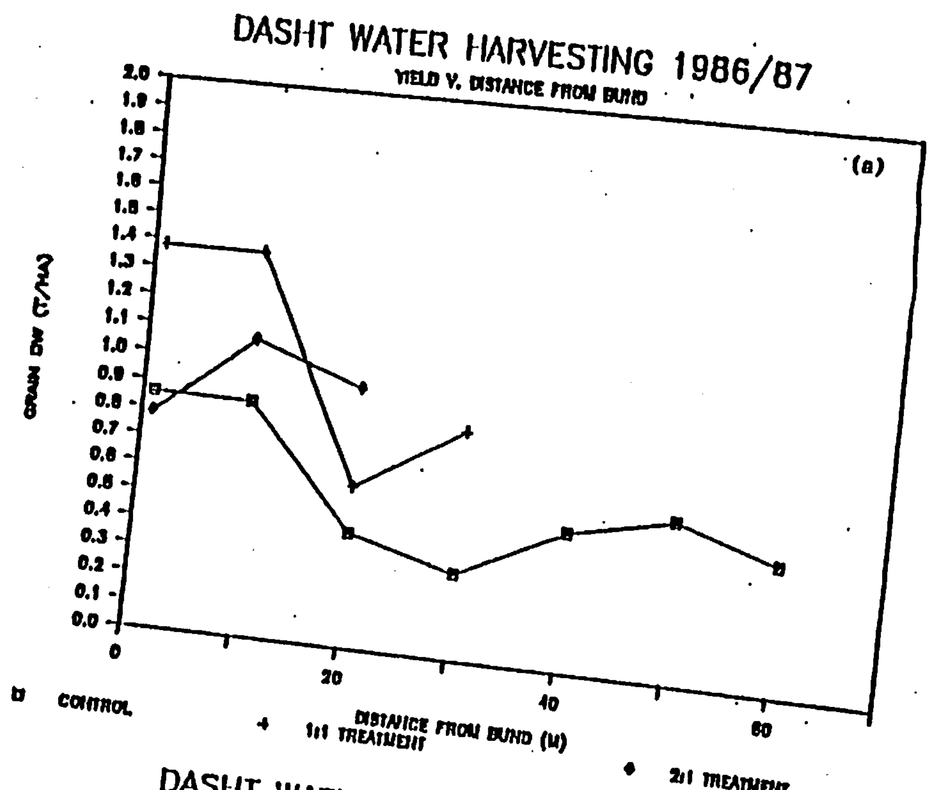


Table 10. Local wheat straw and grain yields (kg/ha dry weight), Water harvesting trial, Dasht 1986/87 on CROP+CATCHMENT area basis.

Treatment	Straw	Grain
Control	1531	562
1:1 crop:catchment area	1532	718
2:1 crop:catchment area	904	397
Mean	1322	559
S.E.	249.6	117.8
Probability	NS	NS

The different planting and catchment areas of the three treatments require different amounts of specific agricultural activities. Table 11 indicates the number of hours performed by agriculture activity and the associated cost for each treatment. The calculation of the net benefits (Table 12) indicates that the control is dominated by treatment 1:1 (higher net benefit and lower cost). The net benefits from treatment 1:1 are over twice that of treatment 1:2 with a marginal rate of return of 270%. Although the results are for one year only, the economic analysis suggests that the water harvesting intervention shows promise and that further experimentation is warranted.

Figure 6. Grain (a) and straw (b) yields versus distance from the earthbank (bunds), Dasht Water Harvesting Trial 1986/87



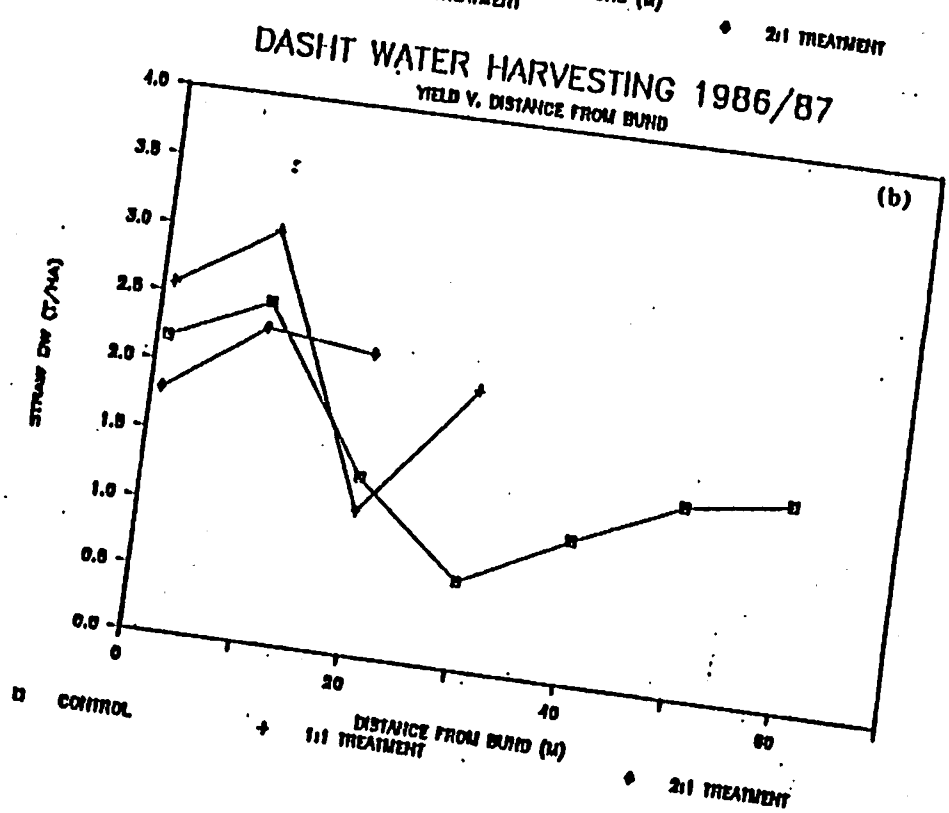


Table 11. Water harvesting trial labour hours and costs, Dasht, 1986-87.

	Treatments		
	Control	1:1	1:2
	----------hrs/ha----------		
Tillage (tractor)	6.1	3.1	2.0
Planting (man & camel)	12.4	6.2	4.1
Harvesting (man)	22.2	28.4	15.7
Threshing (man)	52.9	67.5	37.3
Threshing (camel)	26.4	33.7	18.7
Catchment maintenance (man)	0	10.0	15.0
First year Catchment set-up time (tractor)	-	5.2	7.4
	----------Rs./ha----------		
Tillage (tractor)[1]	366	186	120
Planting (man & camel)	99	50	33
Harvesting (man)	56	71	39
Threshing (man)	132	169	93
Threshing (camel)	145	185	103
Catchment maintenance	0	25	38
Set up cost[2]	0	82	117
Seed costs[3]	200	100	67
Total	998	868	610

1 Tractor rental Rs. 60/hr, labour costs Rs.2.5/hr, camel cost Rs.5.5/hr.

2 Tractor rental x set up time amortized over five years at 10 percent.

3 Seed costs = 100kg/ha seed rate x Rs. 2/kg.

Table 12. Economic analysis of water harvesting trial, Dasht, 1986-87.

	Treatments		
	Control	1:1	1:2
Grain yield, kg/ha	562	718	397
Straw yield, kg/ha	1531	1532	904
Gross benefits, Rs.[1]	1890	2202	1246
Costs, Rs./ha	998	868	610
Net benefits, Rs./ha	892	1334	636

[1] Gross benefits = grain yield/ha x price of Rs.2/kg plus straw yield/ha x price of Rs.0.5/kg.

WHEAT PRODUCTION.

The major trial looking at wheat production examined the response of the local and a PARC recommended "improved" variety, Zarghoon, to N, P and K fertilizers, and to weeding. Trial design was 2**5 factorial combination of treatments with 1 replicate at each site. Fertilizer application: 40 kg/ha of N as ammonium nitrate applied as 10 kg/ha mixed with the seed in the seedbed and 30 kg/ha topdressing in late February; 60 kg/ha P_2O_5 triple superphosphate mixed with the seed in the seedbed; 60 kg/ha K as potassium sulphate mixed with the seed in the seedbed.

Results are presented in Tables 13 and 14. In 1985/86 the seedlings did not emerge until February and so avoided any cold stress in that season. The Zarghoon variety produced greater straw yields and similar grain yields to the local in 1985/86, but in 1986/87 was severely damaged by cold and produced 46% less straw and 34% less grain than the local. In 1986/87 crop growth before Winter was good, and in order to follow farmer practice half of each plot was cut for green fodder in December in Dasht and Kovak, producing 284 and 141 kg/ha fresh weight respectively (no significant effect of treatments, moisture ratios 32% and 38% respectively). This crop cutting had little or no effect on final straw and grain yields in both locations. Only two of the eight trials showed any response to phosphate: the two trials in Dasht in 1985/86. This is much lower than would be expected from the Olsen P values; in 1985/86 a possible explanation is the severe water stress and crop failure recorded in 3 of the 5 trials, but no explanation can be offered at present for the 1986/87 trials. In 1986/87 N fertilizer increased straw and grain yields at each site; the overall increase was 21% and 16% for straw and grain respectively (averaged over both varieties).

Figure 7 illustrates the effects of N and phosphate fertilizer on grain yield of the local variety alone. In 1985/86 N resulted in an overall 17% decrease (not statistically significant), whilst phosphate resulted in an overall 28% increase (statistically significant). In 1986/87 these trends were reversed, with N resulting in an overall 25% increase (statistically significant), and phosphate having no effect.

The poor performance of the recommended Zarghoon variety in autumn sowing is disappointing, but in many parts of upland Baluchistan monsoon rains sufficient to support autumn sowing can be expected only about 3 years in 20 (Rees et al., 1988), so this variety may still have application in some areas. The economic analysis of the 1985-86 wheat fertilizer trials indicated that the net benefits from the local wheat variety treatments in each location were greater than each of the remaining treatments with the exception of the Zarghoon and Zarghoon + N treatments in Dasht on Sailaba land. In the 1986-87 trials, the net benefits from Zarghoon with and without fertilizer were lower than the net benefits from the local variety treatment at each location. The 1986-87 results (Table 15.) however, indicate moderate net benefits and marginal rates of return for the local variety with and without fertilizer - with the exception of the Kovak-uncut treatment. The overall marginal rate of return for 1986-87 is 42%.

Table 13. Straw and grain yields (kg/ha dry weight) of 1985/86 wheat production trials.

Site	Maslakh	Quetta	Dasht S[1]	Dasht K	Mastung	Mean	S.E.	Prob.
	Straw dry weight (kg/ha)							
Local var.	213	224	490	514	165	321		
Zarghoon var.	247	310	554	683	231	405	18.4	<0.1%
-N fertilizer	250	274	500	565	179	354		
+N fertilizer	210	261	544	633	217	373	18.4	NS
-P fertilizer	232	255	504	559	175	345		
+P fertilizer	228	280	540	639	221	382	18.4	NS
-K fertilizer	253	263	570	670	216	394		
+K fertilizer	207	272	475	528	180	332	18.4	<5.0%
-Weeding	216	283	546	655	203	381		
+Weeding	244	251	498	543	193	346	18.4	NS
Expt. mean	230	267	522	599	198	363	29.1	<0.1%
	Grain dry weight (kg/ha)							
	Maslakh	Quetta	Dasht S	Dasht K	Mastung	Mean	S.E.	Prob.
Local var.	31	34	210	371	30	135		
Zarghoon var.	53	20	266	309	22	134	12.3	NS
-N fertilizer	53	24	213	380	27	140		
+N fertilizer	30	28	262	300	26	129	12.3	NS
-P fertilizer	50	27	203	265	27	114		
+P fertilizer	33	25	272	415	26	154	12.3	<5.0%
-K fertilizer	47	25	229	360	29	139		
+K fertilizer	36	27	246	314	24	129	12.3	NS
-Weeding	39	32	231	314	30	129		
+Weeding	45	20	245	366	23	140	12.3	NS
Expt. mean	42	26	238	340	26	134	19.4	<0.1%
Olsen P (ppm)	4.4	7.2	3.8	4.0	3.3			
Kjeld. N (ppm)	320	418	386	356	299			

[1] Dasht S and Dasht K - Dasht "sailaba" and "kushkaba", respectively.

Table 14. Straw and grain yields (kg/ha dry weight) of 1986/87 wheat production trials.

Site	Khuzdar	Straw dry weight (kg/ha) Dasht Uncut[1]	Dasht Cut	Kovak Uncut	Kovak Cut	Mean	S.E.	Prob.
Local var.	770	1680	1587	1008	1212	1251		
Zarghoon var.	628	968	950	699	639	777	44.6	<0.1%
-N fertilizer	564	1186	1106	877	806	908		
+N fertilizer	833	1462	1430	829	1045	1120	44.6	<0.1%
-P fertilizer	675	1342	1220	915	907	1012		
+P fertilizer	723	1306	1316	791	944	1016	44.6	NS
-K fertilizer	651	1355	1282	881	922	1018		
+K fertilizer	746	1293	1255	825	929	1010	44.6	NS
-Weeding	734	1232	1187	789	929	974		
+Weeding	664	1416	1350	918	923	1054	44.6	NS
Expt. mean	699	1324	1268	853	926	1014	70.5	<0.1%

	Khuzdar	Grain dry weight (kg/ha) Dasht Uncut	Dasht Cut	Kovak Uncut	Kovak Cut	Mean	S.E.	Prob.
Local var.	566	568	618	357	377	497		
Zarghoon var.	345	500	440	247	216	350	16.9	<0.1%
-N fertilizer	379	506	505	286	267	389		
+N fertilizer	532	562	553	318	326	458	16.9	<0.1%
-P fertilizer	444	546	534	290	271	417		
+P fertilizer	467	522	524	314	322	430	16.9	NS
-K fertilizer	428	583	533	342	308	439		
+K fertilizer	483	485	525	262	285	408	16.9	NS
-Weeding	486	535	536	292	288	427		
+Weeding	425	534	522	312	305	419	16.9	NS
Expt. mean	455	534	529	302	296	423	29.9	<0.1%
Olsen P (ppm)	5.5	5.7		7.8				
Kjeld. N (ppm)	366	459		581				

[1] Uncut, Cut - half of each plot was cut for green fodder in December.

Figure 7. Local wheat grain yields + N; + phosphate, site abbreviations are given in Tables 13 and 14.

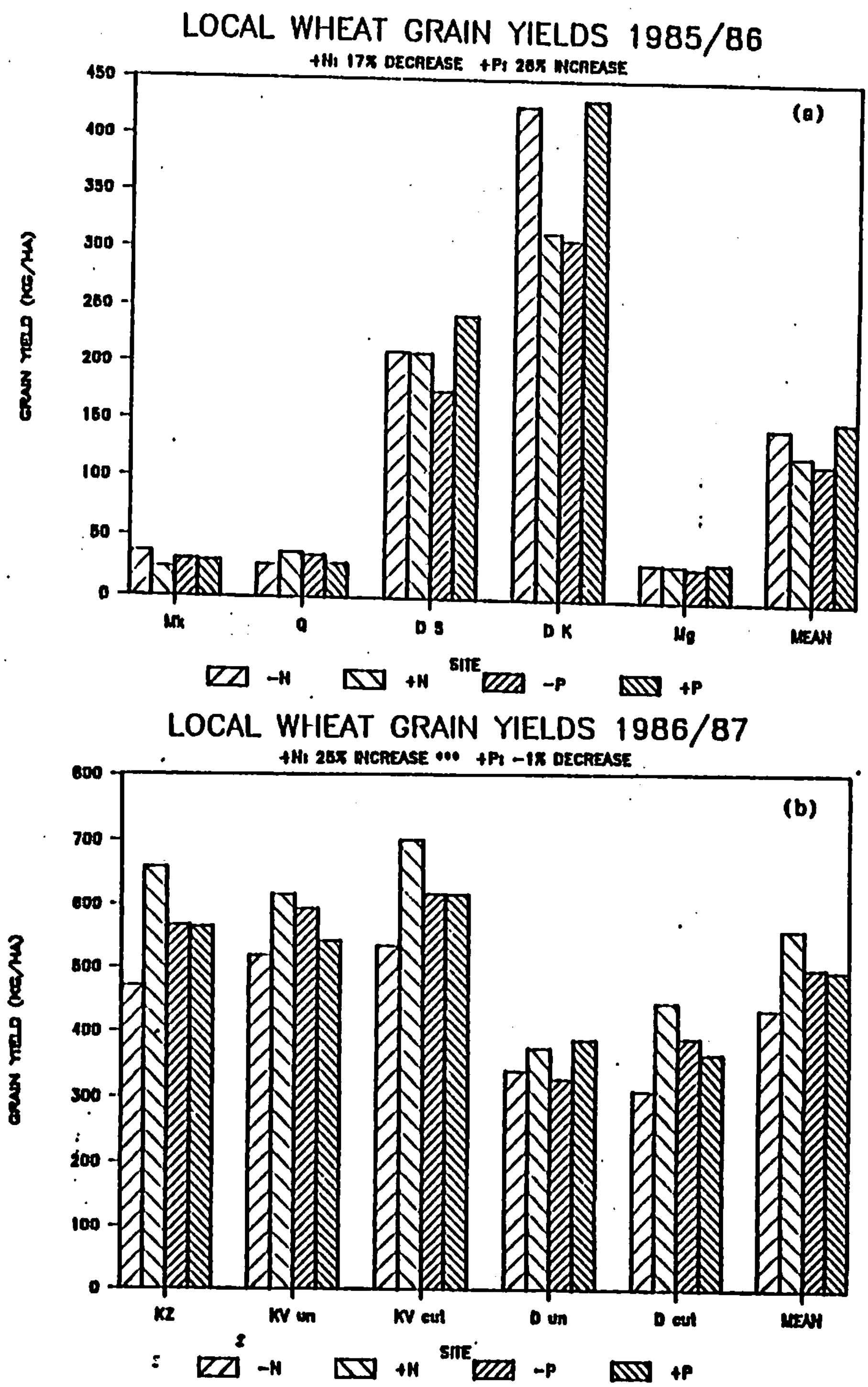


Table 15. Net benefit analysis of wheat soil fertility trials at Khuzdar, Dasht and Kovak, 1986-87.

Location	Treatments[1] Local	Local + N	Marginal Rate of Return
	------ Rs./ha ------		
Khuzdar	1263[2]	1509	97%
Dasht-uncut	1752	1938	73%
Dasht-cut[3]	2028	2195	66%
Kovak-uncut	1182	992	-
Kovak-cut	1534	1656	46%
Mean	1552	1658	42%

[1] N = 40 kg/ha 26-0-0 fertilizer.

[2] Grain prices of Rs.2/kg, straw prices of Rs.0.5/kg, green fodder prices of Rs.0.75/kg and fertilizer cost of Rs. 262/ha (Rs.84.5/50kg 26-0-0) were used to calculate the net benefits.

[3] Crop growth cut for fodder in December.

More information from subsequent trials is required before any conclusions about phosphate fertilizer application can be drawn. The results suggest that in "good" rainfall years a response to N fertilizer can be expected, but not in "poor" years. As yet we do not have sufficient information to enable us to define "good" and "poor" years precisely; however, a flexible approach could be adopted: apply 10 kg/ha with the seed into the seedbed, and only apply a subsequent topdressing in late February if growing conditions appear to be favorable, eg.(a) good crop growth following autumn sowing; (b) good February rainfall; or (c) significant additional flood water from either streamflow or a treated catchment area.

BARLEY PRODUCTION.

The main barley production trial consisted of five exotic varieties compared with the local, all +/- fertilizer (40 kg/ha of N as ammonium nitrate, 10 kg/ha in the seedbed, 30 kg/ha topdressed in late February; 60 kg/ha P_2O_5 as triple superphosphate in the seedbed). In 1986/87 a second local variety was included. As discussed above seedling emergence did not occur until February in the 1985/86 trials, but following the good monsoon rains of August 1986 autumn crop growth was good and half of each plot was cut for green fodder in Dasht and Kovak, in order to quantify this farmer practice.

Crop cutting in 1986/87 produced 414 and 162 kg/ha in Dasht and Kovak respectively (no significant treatment effects, moisture ratios 24 and 37 % respectively); but in contrast to wheat, this did result in some reduction in final straw and grain yields: 160 kg/ha (12 %) reduction in straw, and 84 kg/ha (11 %) reduction in grain.

The exotic varieties "Arabic abiad" and "Arabic aswad" both produced somewhat more straw and grain than the local in 1985/86 (Table 16), but in 1986/87 produced somewhat less straw and more grain than the local. The data so far does not suggest that any of the exotic varieties can greatly outyield the local landrace. In 1985/86 fertilizer did not produce any significant increases in straw or grain yield (Figure 8, Tables 16 and 17) but in 1986/87, the "good" rainfall year, grain and straw yields were increased overall by 245 (19%) and 128 (16%) kg/ha, respectively.

In 1985/86 yields were generally low and fertilizer application reduced net benefits in all cases. Net benefits for the local and the best two "improved" varieties, with and with out fertilizer, are presented in Figure 8. Barley, fodder and straw prices used in the calculations were Rs. 1.75/kg, Rs. 0.75/kg and Rs. 0.5/kg respectively. Fertilizer costs of Rs. 262/ha for 26-0-0 and Rs. 254/ha for 0-46-0 were used.

The "improved" variety, Arabic Abiad gave higher net benefits than the local variety in four out of five trials without fertilizer, and in three out of five trials with fertilizer. The overall mean net benefits for the local variety, Arabic Abiad and Arabic Aswad without fertilizer were 1827, 2112 and 1815 Rupees/ha respectively, and 1544, 1730 and 1640 Rupees/ha with fertilizer.

The data indicate that fertilizer application <u>reduced</u> net benefits even though straw and grain yields were significantly increased. The wheat production trials data suggest that in these same fields any fertilizer response in 1986/87 can be attributed to N alone. Thus , if it can be claimed that the application of N fertilizer would have given the same yield response without the application of P, the mean net benefit would be increased to 1859 Rupees/ha but still below the mean net benefit without fertilizer.

This negative affect of fertilizer is in contrast to the wheat trials which showed higher net benefits for N application in 1986/87. This can be attributed to two factors: (1) the lower grain price for barley (1.75 Rs./ha compared to 2 Rs./ha) and (2) the barley, although having higher overall grain yields than the wheat, showed a lesser percent grain response to fertilizer (24% compared to 18%).

These results do not hold much promise for increasing income from barley by fertilizer application, despite increases in biological yield in "good" years at least. The generally superior performance of "Arabic abiad", however is encouraging and supports the need to continue these trials for at least another year to confirm/deny results obtained so far.

Table 16a. Straw dry weights (kg/ha) 1985/86 barley variety/fertilizer trials.

Variety	Quetta	Dasht K	Dasht S	Mastung	Mean
LB7	461	395	384	379	405
LB50	558	457	453	366	457
LB90	551	348	437	426	441
Arabic aswad	1253	427	468	393	635
Arabic abiad	1445	380	499	437	690
Dasht local	852	448	532	380	553
Mean	853	412	473	400	530
S.E.	288.4	56.1	77.3	43.1	76.3
Probability	NS	NS	NS	NS	<5.0%
-Fertilizer	839	413	435	374	508
+Fertilizer	869	412	511	427	552
S.E.	88.1	78.1	48.4	13.5	31.5
Probability	NS	NS	NS	<10.0%	NS

Table 16b. Grain dry weights (kg/ha) 1985/86 barley variety/fertilizer trials.

Variety	Quetta	Dasht K	Dasht S	Mastung	Mean
LB7	219	361	149	43	193
LB50	151	340	189	59	185
LB90	197	282	170	43	173
Arabic aswad	246	387	216	40	222
Arabic abiad	357	240	116	76	197
Dasht local	307	244	172	32	189
Mean	246	305	163	50	193
S.E.	60.2	64.9	35.0	16.8	23.6
Probability	NS	NS	NS	NS	NS
-Fertilizer	316	305	167	62	207
+Fertilizer	176	305	159	37	179
S.E.	60.2	32.8	14.9	14.2	10.4
Probability	<5.0%	NS	NS	NS	<9.0%
Olsen P(ppm)	8.2	6.6	7.3	8.5	
Kjeld. N(ppm)	580	595	616	238	

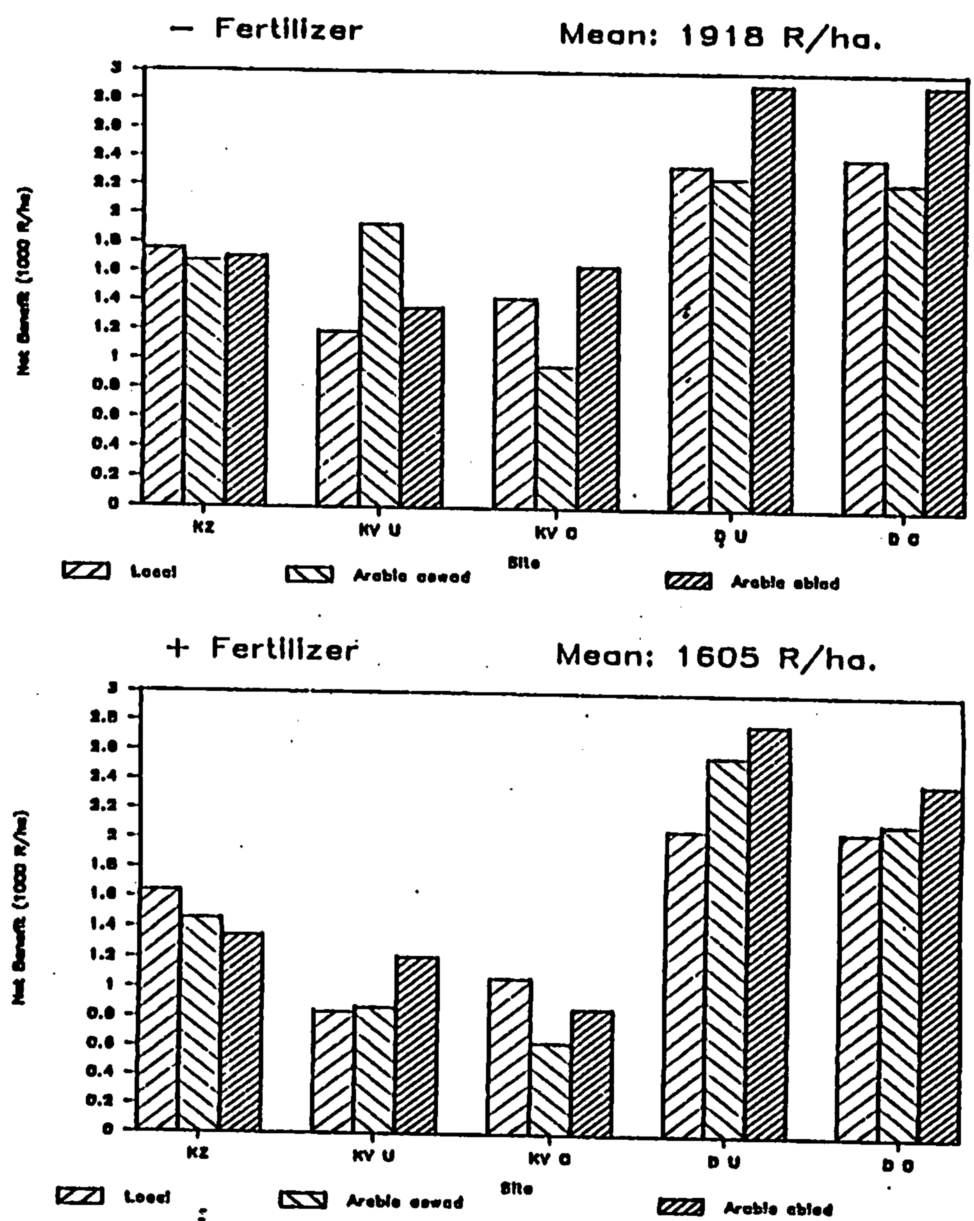
Table 17a. Straw dry weights (kg/ha) 1986/87 barley variety/fertilizer trials.

Variety	Khuzdar	Kovak Uncut[1]	Kovak Cut crop	Dasht Uncut	Dasht Cut drop	Mean
LB7	1553	912	786	1641	1440	1228
LB50	463	1096	891	1617	1216	1057
LB90	819	1232	899	1556	1729	1247
Arabic aswad	948	1111	742	1305	958	1013
Arabic abiad	1305	1175	1155	1874	1701	1442
Dasht local	1564	1190	1244	1901	1978	1576
Khuzdar local	1330	1516	1055	1291	1386	1316
Mean	1140	1176	967	1598	1487	1274
S.E.	187.3	177.2	137.5	269.0	182.2	128.0
Probability	<0.1%	NS	NS	NS	<1.0%	<0.1%
-Fertilizer	999	1114	864	1399	1381	1151
+Fertilizer	1282	1239	1071	1796	1593	1396
S.E.	100.2	94.7	73.5	143.8	97.4	46.7
Probability	<6.0%	NS	<6.0%	<7.0%	NS	<0.1%

Table 17b. Grain dry weights (kg/ha) 1986/87 barley variety/fertilizer trials

Variety	Khuzdar	Kovak Uncut	Kovak Cut crop	Dasht Uncut	Dasht Cut crop	Mean
LB7	976	400	383	1224	1198	836
LB50	755	409	470	1057	1037	746
LB90	763	707	345	1155	1218	837
Arabic aswad	775	607	323	1159	944	762
Arabic abiad	706	545	468	1245	1002	793
Dasht local	653	390	437	868	686	607
Khuzdar local	740	665	416	965	914	740
Mean	767	532	406	1096	999	760
S.E.	79.2	118.8	75.1	148.1	166.7	80.6
Probability	NS	NS	NS	NS	NS	<7.0%
-Fertilizer	682	494	393	988	921	696
+Fertilizer	852	570	419	1204	1078	824
S.E.	42.4	63.5	40.1	79.2	89.1	29.4
Probability	<1.0%	NS	NS	<7%	NS	<1.0%
Olsen P (ppm)	7.0	5.4		5.4		
Kjeld. N (ppm)	411	583		390		

Figure 8. Net benefits of fertilizer application to barley varieties in 1986/87, site abbreviations are given in Table 17



LENTIL/*VICIA* FORAGE LEGUME PRODUCTION.

Two trials are reported in this section. In 1985/86 only a small quantity of seed was available and a simple variety trial was conducted at one site in Dasht. The exotic lentils in this trial performed poorly and were replaced in 1986/87 with other varieties. In 1986/87 three species of *Vicia*, three exotic lentil varieties and a local lentil variety were compared at several sites with and without triple superphosphate fertilizer (60 kg/ha P_2O_5 sown with the seed), and with and without inoculum of N-fixing bacteria. Tables 18 and 19 present the results.

In 1985/8 severe sand storms stripped the legume crops of all their leaves so straw dry weights could not be determined, but the above-ground dry weights at flowering were taken only two weeks prior to final seed harvest and so can be used to provide an estimate of straw dry weight (ie. straw = total above-ground dry weight - grain; Table 18). Differences between varieties/species in above-ground dry weights were not statistically significant, but differences in seed yield were, with the three *Vicia* species producing significantly more than the lentils. Yields were very low (crop failure) in all cases.

In 1986/87 the trials were sown in September/October and good early growth resulted. The Dasht "sailaba" site provides a dramatic example of the benefits of the "sailaba" water harvesting system at its best (Table 19).

The exotic lentils, *Vicia narbonensis*, and to a lesser extent, *V. sativa*, were all severely damaged by cold stress in Kovak, Dasht and Quetta, but not in Khuzdar. *V. villosa* ssp. *dasycarpa* produced remarkably high straw yields, particularly at Khuzdar and the Dasht "sailaba" site. *V. sativa* produced straw yields somewhat less than that of the local lentil. The high straw yields of *V. villosa* ssp. *dasycarpa* were not reflected in high seed yields which were only slightly higher than that of the local lentil. Observations suggested that in favorable growing conditions the 100 kg/ha seed rate used in these trials should be reduced, at least for *V. villosa* ssp. *dasycarpa*, in order to increase seed yields. Further agronomic trials on this subject are planned.

Inoculation increased straw and seed yields significantly at 3 of the 4 sites, but apparently reduced seed yields at the Dasht "sailaba" site. No explanation for this can be offered, unless it was just a random effect. Phosphate fertilizer had no effect on straw or seed yields, even though Olsen P values varied between 4 and 7 ppm.

The inoculum response is examined in more detail in Figure 9, where straw and grain yields of the local lentil, *V. villosa* ssp. *dasycarpa* and *V. sativa* with and without inoculum are plotted. Inoculum increased lentil seed yield at all three sites and straw at two of the three sites; straw yields of *V. villosa* were increased at all three sites and grain at two; whilst *V. sativa* showed increased straw and seed yields at Dasht and Kovak, but not at Khuzdar. Overall responses at these three sites were statistically significant for both straw and seed yields.

Net benefits for the local lentil and the more promising forage legumes *V. villosa* ssp. *dasycarpa* and *V. sativa* with and without inoculum are presented in Table 20. The increase in the overall mean net benefits from the inoculated treatment at Khuzdar, Kovak and Dasht-K locations are large. Marginal rates of return are several times above that of a benchmark 40% return on capital that farmers seek before adopting an intervention (Perrin *et al.*). The return to labour is also substantial because it only requires 2 to 3 hours/ha additional time to inoculate the seed.

The net benefits were calculated with the forage legume grain price equal to the lentil grain price. Because the forage legumes are new interventions in Baluchistan, a legume grain price has not been established. It is possible that the forage legume price could be lower than the lentil price but would have to be 40% to 50% lower to affect the overall mean results presented in Table 20.

V. villosa appears from these results to be a very promising potential addition to the rainfed farming system of upland Baluchistan; whilst V. sativa should not be rejected as yet. Inoculation with N fixing bacteria appears to be a very promising way of increasing legume production at most sites, until (if) sufficient bacterial populations can be built up in the soils.

Table 18. Total above ground dry weight at flowering and final grain yields, Lentil/Vicia legume trial, Dasht (kushkaba) 1985/86. (Wind severely damaged straw at maturity.)

	A.g. dw (kg/ha)	Grain dw (kg/ha)
Lentil local var.	236	11[a]
Lentil ILL241	302	3[a]
Lentil ILL2580	118	4[a]
Lentil ILL2581	476	1[a]
Lentil ILL4403	338	1[a]
V. villosa ssp. dasycarpa.	184	34[b]
V. narbonensis.	198	30[b]
V. sativa.	316	16[b]
Mean	258	12
S.E.	131.0	6.3
Probability	NS	<1.0%

a, b - significantly different at P< 5.0%.

Table 19a. Straw yields (kg/ha dry weight), Lentil/*Vicia* legume trial 1986/87.

Site	Khuzdar	Kovak	Dasht K[1]	Dasht S	Mean
Lentil local var.	403	359	1011	3684	1364
Lentil ILL3516	606	0	421	0	257
Lentil T86	506	0	0	0	127
Lentil S86	604	7	184	0	199
V. villosa ssp. *dasycarpa*.	1778	800	1194	7294	2767
V. narbonensis.	348	185	0	401	233
V. sativa.	366	114	772	3645	1224
Mean	659	209	512	2146	881
S.E.	162.9	63.3	146.5	425.0	120.6
Probability	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
-Inoculum	521	147	345	2312	831
+Inoculum	796	271	678	1980	931
S.E.	87.1	33.8	78.4	227.2	64.5
Probability	<5.0%	<1.0%	<0.3%	NS	NS
-P fertilizer	691	211	485	2426	953
+P fertilizer	626	208	538	1867	810
S.E.	87.1	33.8	78.4	NS	64.5
Probability	NS	NS	NS	NS	NS

Table 19b. Grain yields (kg/ha dry weight), Lentil/*Vicia* legume trial 1986/87

Site	Khuzdar	Kovak	Dasht K	Dasht S	Mean
Lentil local var.	159	219	574	1003	489
Lentil ILL3516	249	0	113	0	91
Lentil T86	191	0	0	0	48
Lentil S86	183	9	11	0	51
V. villosa ssp. *dasycarpa*.	156	347	342	1201	512
V. narbonensis.	98	224	0	78	166
V. sativa.	46	120	368	1255	447
Mean	155	131	201	505	258
S.E.	24.0	39.3	42.5	119.3	34.1
Probability	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
-Inoculum	133	57	152	610	247
+Inoculum	177	205	251	400	269
S.E.	12.8	21.0	22.7	63.8	18.2
Probability	<5.0%	<0.1%	<0.3%	<5.0%	NS
-P fertilizer	145	120	192	538	258
+P fertilizer	165	142	210	472	258
S.E.	12.8	21.0	22.7	63.8	18.2
Probability	NS	NS	NS	NS	NS

[1] Dasht K, Dasht S - "kushkaba" and "sailaba" sites in Dasht.

Figure 9(a)

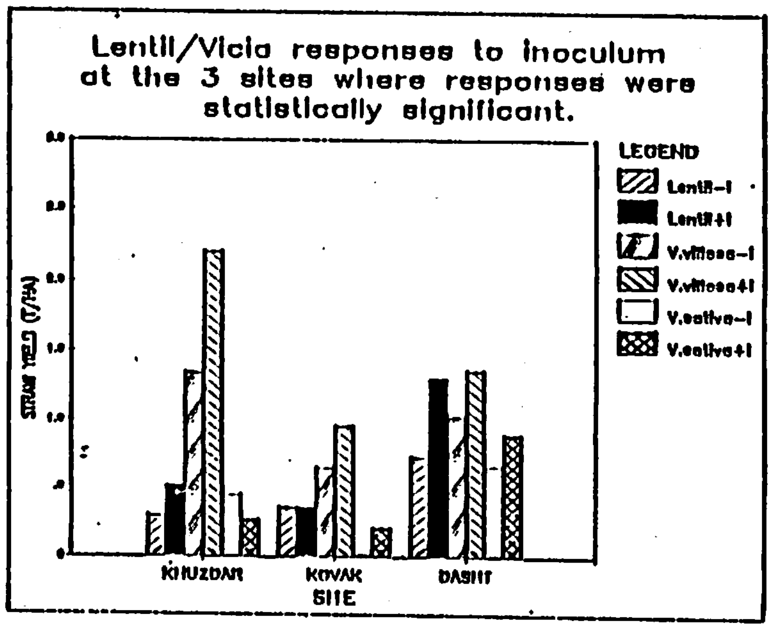


Figure 9(b)

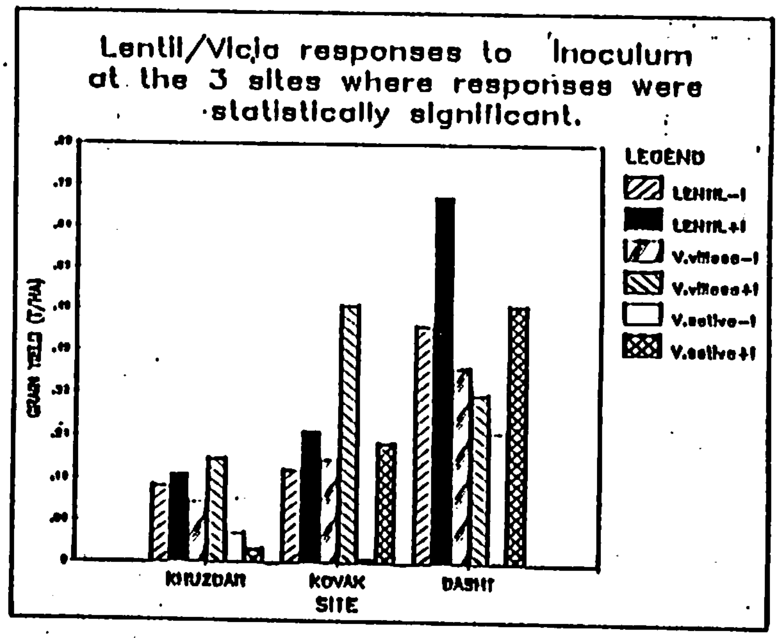


Table 20. Net benefit analysis of lentil/legume trials with and without inoculum at Khuzdar, Kovak and Dasht, 1986-87.

Treatments[2]	Location[1]				
	Khuzdar	Kovak	Dasht K	Dasht S	Mean[3]
	Net Benefits[4] (Rs./ha)				
Local lentil	1053	1285	3037	10502	1792
Local lentil, I	1260	1633	4759	6028	2551
VV	1663	1606	2779	12196	2016
VV, I	2712	3377	2739	11928	2943
VS	671	76	1854	12233	867
VS, I	350	1374	3326	6999	1683

1 K = Khushkaba land and S = Sailaba land.

2 VV = *V. villosa* ssp. *dasycarpa*; VS = *V. sativa*.; I = inoculated seed.

3 The mean of Khuzdar, Kovak and Dasht-K locations which show a positive significant response to inoculation. The response to inoculation at the Dasht-S location is negative and non-significant.

4 Grain prices of Rs. 5.5/kg, fodder prices of Rs. 0.75/kg and an inoculum cost of Rs. 35/ha were used in the net benefit calculations.

TILLAGE.

Tillage research in rainfed areas of the Punjab and North West Frontier provinces of Pakistan have demonstrated considerable biological and economic advantages to deep plowing (20 cm+) with moldboard plows compared to the local practice of several shallow tillage operations with a spring-tine cultivator (Byerlee *et al.* 1986). In upland Baluchistan a preliminary survey indicated that slightly over 50% of dryland farmers use tractors for at least part of their plowing activities, 40% plow only once before planting, and 60% plow twice. All respondents used spring-tine cultivators rather than moldboard plows (Rees *et al.*, 1988). The high bulk densities, predisposition of the soils to crusting, and apparently low infiltration rates suggest that deep tillage might also be beneficial in upland Baluchistan.

In 1985/86 a single tillage trial was conducted in Dasht, comparing a single spring- tine cultivator operation (10 cm depth chisel plowing) with a single moldboard operation (20 cm depth). These operations were carried out in dry soil in October 1985 when it was apparent that there would be no monsoonal rains. The seedbeds were prepared by the local practice of dragging a plank behind the tractor over the soil to break down the clods to a suitable size. Some farmers with tractors were also plowing dry soil at this time, but the majority, particularly those relying upon animal draft power, delayed plowing until January/ February, after rain.

Table 21 shows the results of this trial. Both straw and seed yields were significantly higher with moldboard plowing, and this was consistent for all crops and varieties.

Table 21. Straw and grain yields (kg/ha dry weight) tillage trial Dasht 1985/86.

Crop	Straw (kg/ha) 10 cm chisel	Straw (kg/ha) 20 cm mold-board	Straw (kg/ha) Mean	Grain (kg/ha) 10 cm chisel	Grain (kg/ha) 20 cm mold-board	Grain (kg/ha) Mean
Local wheat	224	385	304	72	143	108
Zarghoon wheat	432	390	411	58	103	81
PARC81 wheat	314	458	386	117	220	168
Local barley	376	412	394	139	253	196
Local lentil	94	102	98	91	120	106
Mean	288	350	319	95	168	132
S.E.	13.7		27.5		9.1	11.8
Prob.	<9.0%		<0.1%		<3.0%	<0.1%

In 1986/87 the trial was modified to include two extra treatments: plowing after rain (traditional 10 cm chisel plowing with a spring-tine cultivator); and deep (20 cm) chisel plowing before rain to compare with the moldboard plowing before rain.

Results are shown in Table 22. Tillage operations did not have any effect on straw and grain yields at any location. This can be explained by reference to the rainfall pattern and intensity: the exceptionally heavy monsoon rains occurred after the tillage operations, causing the soil to revert to its untilled state. Any possible benefits of improved infiltration were not apparent in final yields, perhaps because the unusual size of the monsoonal rains resulted in good soil water storage in all treatments, swamping any tillage effects.

The tillage experimental results are obviously not very encouraging so far. Trials in subsequent years' will again be modified to include moldboard plowing after rain (followed by "planking" to smooth the soil surface and reduce evaporative losses), and comparison with plowing by animal draft in an attempt to quantify the biological and economical benefits of animal/ tractor plowing.

Table 22. Barley straw and grain yields (kg/ha dry weight), tillage trials 1986/87. (Note severe grain losses to birds at Dasht S site.)

	Straw dw (kg/ha)				
	Khuzdar	Dasht K	Dasht S uncut	Dasht S cut	Mean
After rain:					
10 cm chisel	1141	1412	1351	1655	1390
Before rain:					
10 cm chisel	1160	1047	1312	1045	1141
20 cm chisel	1186	1341	1131	976	1158
20 cm m'board	1083	1432	1372	1133	1256
Mean	1143	1307	1292	1202	1231
S.E.	76.5	150.0	412.0	434.2	160.5
Probability	NS	NS	NS	NS	NS
-weeding	1093	1283	1060	1053	1122
+weeding	1192	1332	1523	1352	1350
S.E.	67.7	71.4	185.2	135.2	62.4
Probability	NS	NS	NS	NS	<1.0%

	Grain dw (kg/ha)				
	Khuzdar	Dasht K	Dasht S uncut	Dasht S cut	Mean
After rain:					
10 cm chisel	1470	495	95	106	542
Before rain:					
10 cm chisel	1378	399	91	105	493
20 cm chisel	1124	459	93	82	439
20 cm m'board	1233	338	180	51	451
Mean	1301	423	115	86	481
S.E.	148.3	81.1	37.9	31.0	44.0
Probability	NS	NS	NS	NS	NS
-weeding	1293	465	130	81	492
+weeding	1310	381	100	90	470
S.E.	113.9	31.7	24.5	13.2	30.4
Probability	NS	NS	NS	NS	NS

CROP COMPARISONS.

The 1985/86 tillage trial included a comparison of wheat, barley and lentil crops (Table 21). Mean straw yields for these 3 crops were 304, 394 and 98 kg/ha respectively, and grain yields were 108, 196 and 106 kg/ha respectively. As expected the barley crop was the more productive of the two cereals. Table 23 below compares results from separate trials where these were conducted on the same field in 1986/87. In Khuzdar and Dasht barley produced considerably more straw and grain than wheat, but not in the drier site, Kovak. It must be emphasized that it is not possible to strictly distinguish between site effects and crop effects from this data, but as the assignment of trials to different parts of each field was random, the comparisons should be reasonably realistic. V. villosa ssp. dasycarpa produced considerably more straw than lentil, but similar amounts of seed. V. villosa did not produce more straw than barley. Straw and seed of lentil and vetches have a higher nutritive value than that of wheat and barley (eg. ICARDA 1986). Lentil seed, at least, commands a higher price than wheat or barley grain, so these crops may be useful alternatives to barley and wheat, despite their lower productivities. The differences in wheat and barley productivities are not very great, which perhaps helps to explain why dryland farmers of upland Baluchistan prefer to grow wheat at present, using the straw as an animal feed and the grain for home consumption. Further work is required, and planned, to compare these two crops in upland Baluchistan dryland conditions, and to describe and evaluate farmers' perspectives of these two crops, but this initial data does not suggest that any marked improvements in productivity from changing from wheat to barley can be expected. The two legume crops are perhaps more likely to have a role in crop rotations rather than as replacements for wheat.

Table 23. Comparison of yields of wheat, barley, lentils and V. villosa ssp. dasycarpa, 1986/87. Results from separate trials conducted on the same fields.

Site	Khuzdar	Kovak Uncut	Kovak Cut	Dasht K Uucut	Dasht S Cut	Mean
Local wheat						
straw	770	1680	1587	1008	1212	1251
grain	566	568	618	357	377	497
Local barley						
straw	1564	1190	1244	1901	1978	1274
grain	653	390	437	868	685	607
Local lentil						
straw	403	359	---	1011	---	443
grain	159	219	---	574	---	238
V. villosa						
straw	1778	800	---	1194	---	943
grain	158	347	---	342	---	212

GERMPLASM EVALUATION

INTRODUCTION

In upland Baluchistan the severity of temperature conditions and the considerable uncertainty of reliable seasonal precipitation requires the examination of a wide range of genetic resources. The objective is to select new crop species and lines suitable for growth under non-irrigated conditions, to diversify the present single crop (breadwheat) system; and to investigate the potential for additional livestock feed production. Meeting the latter challenge will mitigate a chronic deficiency in the livestock economy of Baluchistan. In addition, following extremely severe outbreaks of rust in cereal crops in 1976 and 1983, there is an urgent need for the development of a wider genetic base incorporating disease resistant qualities.

The germplasm evaluation program developed at AZRI is jointly sponsored by the Provincial Agricultural Research Institute at Sariab, Quetta. In this program we are using the large variations in altitude found in the non-irrigated areas of upland Baluchistan (2200-1200m) and different seeding times (autumn and early spring) to impose a wide range of environmental screening pressures on introduced germplasm. Artificial disease inoculation has not been used to date because local disease races are unique, and are still being identified and cultured. This will allow screening in future under high disease pressure inoculated conditions conducted in cooperation with the PARC Central Diseases Research Institute at Karachi.

Three principal screening locations were used in the 1986/87 season and will be retained until 1988/89: The Provincial Agricultural Research Institute at Sariab , Quetta (1750m elevation); farmer's fields at Kan Metarzai near Muslimbagh (2200m) and Ferozabad (1200m) near Khuzdar (Figure 1). The Arid Zone Research Institute headquarters at Quetta is a minor additional location.

Seeding times are determined by following the practices of local farmers. Thus, the first seeding time is in autumn (late September or early October) only if summer monsoonal rains occur (approximate recurrence 1-2 years in ten at Quetta). If they do not, irrigation water is used to simulate this condition to allow pre-winter emergence. The second seeding time is late January or early February following winter rains. The precise time is determined by the degree of cold exposure at each site. Soil fertility conditions are generally poor and are usually amended by the addition of fertilizer at a conservative rate (usually 60 kg/ha N and 60 kg/ha P_2O_5 for cereal crops).

RESULTS

DUAL PURPOSE CROPS

1. Lentils: This is not a major crop under non-irrigated conditions in Baluchistan. However, in the subsistence wheat-based system, presently used by farmers, the addition of a dual purpose crop such as lentil would help diversify crop rotations. The local landrace presently being grown is well adapted to the severe temperature conditions, but has the disadvantage of being ultra-small seeded. For the previous five years, but with little success, ICARDA has been seeking lentil lines with larger seed size, which are suitably adapted to the environmental conditions.

In 1986-87 our autumn-planted nurseries at Kan Metarzai and ARI Sariab were heavily damaged by the sudden onset of cold air temperatures (Figure 10) and regrowth percentage became an important screening factor. It was notable, for example at ARI Sariab, that whereas FLIP 84-43L was killed in the autumn planting (Table 24) it was the most successful line in the generally poorer spring-planted crop, achieving 2.25 t/ha dry matter and 0.63 t/ha grain.

This was significantly better than the local check. The results in Table 24 show that for the autumn-planted nursery at ARI Sariab the performance of FLIP 84-14L and FLIP 84-17L was significantly better than the local check. However, these were the only two species showing comparable cold tolerance to the local landrace. Two other lines, FLIP 84-4L and FLIP 84-169L, can be singled out by their performance and yet they attained their production level only on 60-65 % regrowth. In a less severe year they would have promise of even better production. Large seeded material generally did not do as well as small seeded lines.

In the warmer conditions of Ferozabad, and with spring-planting at all locations, productivity levels were lower than shown in Table 24 for ARI Sariab, with 1-2 t/ha dry matter being a common level. This may have been the result of a degree of nitrogen deficiency. In the past nurseries have not been inoculated with Rhizobia sp. for logistic reasons. However, in our trials with the local landrace (Table 25 and 26), it is evident that, for one year at Ferozabad/Khuzdar and for two years at AZRI HQ (Quetta), there has been a large positive response to inoculation in the presence or absence of additional phosphate fertilizer. This conclusion is substantiated by the agronomic data presented in Table 19. In the next season 1987-88, all our nurseries will receive inoculation with Rhizobia sp.

Table 24. International Small Seeded Lentil Yield Trial ARI Sariab (Quetta) - AUTUMN SOWING 1987.

ENT NO.	SELECTION NUMBER	ILL. NO.	COLD TOLER-ANCE	RE-GROWTH (%)	DAYS TO 50% FLOWERING	TDM (KG/HA)	SEED YIELD (KG/HA)	1000 SEED WEIGHT (GM)
1	---	975	4 b	7 d	187 f	1279 ef	85 fgh	39 bcd
2	---	1939	4 b	8 d	198 c	442 fg	65 gh	35 de
3	FLIP 86-32L	6018	5 a	4 d	198 c	554 fg	0 h	32 e
4	FLIP 84-4L	5677	5 a	63 c	205 a	3083 cd	645 bcd	41 abcd
5	FLIP 84-14L	5687	2 d	97 a	194 d	5000 a	822 bc	39 cd
6	FLIP 84-17L	5690	1 e	95 ab	194 d	5750 a	1353 a	41 abcd
7	FLIP 84-43L	5714	5 a	0 d	0 h	0 g	0 h	0 g
8	FLIP 84-49L	5720	5 a	5 d	193 e	563 fg	89 fgh	45 ab
9	FLIP 84-60L	5730	4 b	20 d	186 g	1312 ef	204 fgh	45 abc
10	FLIP 84-61L	5731	4 b	72 abc	198 c	2625 cd	412 defg	46 a
11	FLIP 84-169L	5838	3 c	66 bc	186 g	4657 ab	944 b	40 abcd
12	FLIP 84-13L	5851	3 c	83 abc	186 g	2542 cd	257 efgh	40 bcd
13	FLIP 84-17L	5855	4 b	83 abc	186 g	2750 cd	600 bcde	39 bcd
14	FLIP 85-27L	5865	3 c	97 a	194 d	3750 bc	305 defgh	45 abc
15	FLIP 85-29L	5867	4 b	75 abc	198 c	2173 de	466 cdef	44 abc
16	LOCAL CHECK	---	1 e	98 a	201 b	3542 bc	426 defg	25 f
COEFFICIENT OF VARIATION			5.89%	28.44%	0.14%	27.17%	47.56%	8.59%
STANDARD ERROR			0.12	9.04	0.15	392.39	114.49	1.9

NOTE:- Means followed by different letters are significantly different at

as indicated by "Duncan's New Multiple Range Test".

Figure 10. Minimum air temperatures at AZRI expressed as five day running averages (day 1 = November 1)

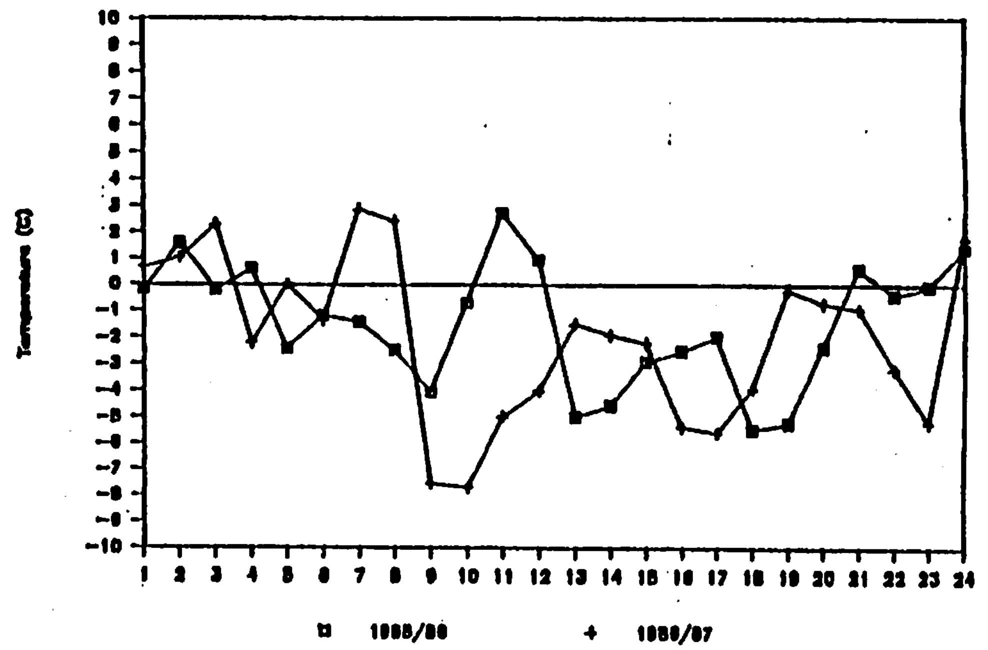


Table 25. Total above ground dry matter at final harvest (kg/ha) of local lentil + or - phosphate (60 kg/ha) and + or - inoculum, Quetta and Khuzdar, 1985/86 and 1986/87.

	Quetta 85-86	Quetta 86-87	Khuzdar 86-87	MEAN	% OF EFFECT
- Phosphate	192.0	2300.0	2553.3	1681.6	-4
+ Phosphate	209.6	2075.0	2558.0	1614.2	
- Inoculum	153.9	1462.5	1936.1	1184.2	+56
+ Inoculum	247.8	2912.5	3175.1	2111.8	
MEAN	200.8	2187.5	2555.6	1648.0	
S.E.	15.96	159.1	218.7	127.7	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	<0.1%	<0.1%	<0.1%	<0.1%	

Table 26. Seed yield at final harvest (kg/ha) of local lentil + or - phosphate (60 kg/ha) and + or - inoculum, Quetta and Khuzdar, 1985/86 and 1986/87.

	Quetta 85-86	Quetta 86-87	Khuzdar 86-87	MEAN	% OF EFFECT
- Phosphate	37.9	620.5	369.8	342.7	
					+3
+ Phosphate	37.9	583.0	435.6	352.2	
- Inoculum	29.8	421.4	246.0	232.4	
					+67
+ Inoculum	46.0	782.1	559.4	462.5	
MEAN	37.9	601.8	402.7	347.4	
S.E.	2.12	35.97	37.37	24.47	
Prob. of Phosphate	NS	NS	NS	NS	
Prob. of Inoculum	<0.1%	<0.1%	<0.1%	<0.1%	

2. Wheat: This is the only crop which is grown widely in upland Baluchistan under non-irrigated conditions. It is grown principally for human consumption, but green grazing/clipping in early winter as well as wheat straw are important sources of animal feed, particularly for draught animals (camels and oxen). Autumn-planted nurseries of both bread and durum wheat at ARI Sariab and Kan Metarzai were heavily damaged by cold with spring and spring x winter material often being killed completely. Some lines were heading before the onset of winter and thus are not suitable for early autumn planting. These included the current local improved check Zarghoon and the ICARDA check Sham 2. Zarghoon was also severely damaged at other locations in agronomy trials (Table 14).

There was little consistency in the results for individual cultivars when autumn-planted, in that those cultivars that did best at Khuzdar were usually killed at ARI Sariab and Kan Metarzai. At ARI Sariab, the entry CHAMBORD/5133/Mt/3KKC/4/Lfn/ND/2*P101/5/Rom/Cc/INIA ICW-HAB1-1610-IAP-3AP-0AP was substantially better than the local landrace. In the absence of any disease pressure on the local landrace the results of our breadwheat nurseries were reasonably encouraging, but this requires further confirmation.

Quite impressive results were obtained for spring-planted durum wheats and yield levels of more than 7 t/ha dry matter and 2 t/ha grain were common at Khuzdar, exceeding the local breadwheat landrace by approximately 25 %. However, wet years of this category, particularly with very heavy and unseasonal rains in May (125 mm at Ferozabad - Figure 4), are very rare (Rees et al., 1988) and the results should be viewed in this context.

3. Chickpeas: All nurseries that were autumn-planted (ARI Sariab and AZRI HQ) were killed by cold. Spring-planted nurseries (ARI Sariab) showed poor emergence, and in consequence, poor productivity.

FORAGE CROPS

1. . Annually sown legumes: These crop species, mostly in the genera *Lathyrus* and *Vicia*, are new introductions to Baluchistan and there is no appropriate local control species. For sake of comparison, we have adopted the Syrian local vetch *V. sativa* Acc. No. 2541 as our control treatment and the local lentil landrace as an associated treatment for yield comparisons.

The nursery was dominated by the performance of *Vicia villosa* ssp. *dasycarpa* Acc. No. 683. This was the highest yielding species at five of the six site by seeding time permutations. When planted in autumn this species showed fairly complete, but not total, resistance to cold damage, and a considerable regrowth potential. Yields of dry forage at maturity of 5-6 t/ha at Kan Metarzai/Khuzdar and over 8 t/ha (Table 27) at ARI Sariab were extremely encouraging. These yields greatly exceeded those of the check line and the associated lentil landrace.

The adaptability of this species appears to be very wide, having performed well in the radically different conditions resulting from autumn and spring planting at ARI Sariab and Khuzdar.

For autumn-planted conditions only a small number of species had sufficient cold adaptability to survive. At ARI Sariab all *Lathyrus* species and *V. narbonensis*, *V. ervillia* and 50 % of all *V. sativa* examined were killed. At Kan Metarzai all species were killed except *V. villosa* ssp. *dasycarpa*. Those *V. sativa* that survived at ARI Sariab varied in their ability to regrow following cold damage (Table 27). This is seen as a major selection criteria for future nurseries. A much wider range of *V. villosa* lines will be tested in the 1987-88 season.

Table 27. Annual Sown Forage Legume Trial ARI Sariab (Quetta) - AUTUMN SOWING 1987

ENT NO.	NAME	ACC. NO.	SEL. NO.	COLD TOLERANCE	REGROWTH (%)	DAYS TO 50% FLOWERING	TDM (KG/HA)	SEED YIELD (KG/HA)
1	VICIA SATIVA	384	2062	4 b	35 c	187 cd	2806 b	223 cd
2	VICIA SATIVA	2	1134	3 c	2 d	0 f	0 f	0 d
3	VICIA SATIVA	709	---	3 c	63 b	187 c	1550 de	375 bc
4	VICIA SATIVA	7	1135	4 b	1 d	0 f	0 f	0 d
5	VICIA SATIVA	507	2017	4 b	53 b	204 b	2375 bcd	274 bc
6	VICIA SATIVA	1652	2086	3 c	67 b	210 a	1688 cde	165 cd
7	VICIA SATIVA	716	---	4 b	25 c	186 d	975 ef	237 cd
8	VICIA SATIVA	1416	---	5 a	0 d	0 f	0 f	0 d
9	VICIA SATIVA	1486	2107	4 b	3 d	0 f	0 f	0 d
10	VICIA SATIVA	2541	LOCAL	4 b	57 b	187 c	2750 bc	493 b
11	VICIA ERVILLIA	2542	---	5 a	0 d	0 f	0 f	0 d
12	VICIA NARBONENSIS	67	---	5 a	0 d	0 f	0 f	0 d
13	VICIA DASYCARPA	683	---	1 d	77 a	177 e	8375 a	1173 a
14	LATHYRUS SATIVUS	347	---	5 a	0 d	0 f	0 f	0 d
15	LATHYRUS OCHRUS	83	384	5 a	0 d	0 f	0 f	0 d
16	LATHYRUS SATIVUS	3	311	5 a	0 d	0 f	0 f	0 d
COEFFICIENT OF VARIATION				6.33%	30.87%	0.42%	47.83%	68.04%
STANDARD ERROR				0.14	4.53	0.22	354.12	72.14

NOTE:- Means followed by different letters are significantly different at the 0.05 level, as indicated by "Duncan's New Multiple Range Tests".

In the spring planted nurseries, where cold was not such a severe problem, a rather wide range of lines, particularly *V. sativa*, performed similarly (Table 28). It appears that a real potential for more widespread introduction of annually sown forage legume species exists in upland Baluchistan.

2. Barley: We have observed the effect of autumn-planting on barley at ARI Sariab. At this location, in the absence of disease pressure, the control treatment performed extremely well, reaching 9.2 t/ha dry matter and 2.45 t/ha of grain. None of the introduced lines was able to approach this level of production. However, yields in nearby agronomy trials on farmer's fields (Dasht - Table 17a and b) were much lower.

With spring planting there was considerable uniformity among lines at both ARI Sariab and Khuzdar. Production levels at Khuzdar were far superior to ARI Sariab due to the very favorable, although atypical, late rains (Figure 4). Yields comparable to autumn planting were thus obtained, but they were not significantly greater than the local check treatment which yielded 8 t/ha dry matter and 2.1 t/ha of grain. The top grain yield at Khuzdar of 2.49 t/ha was recorded by the cross - WI2291/WI2269/ICB78-0594-8AP-1AP-OAP.

It is evident from these results that the local barley landrace is extremely well adapted, but its vulnerability to disease has yet to be assessed under epiphytotic conditions. Until this occurs, the quality of the introduced material will not be apparent and parity in production with the local variety is a commendable level to obtain.

The impressive performance of the local barley, in a wet year, does raise the issue of why farmers are not allocating more of their cereal crop hectarage to barley at the expense of wheat. This is discussed in the Agronomy Section of this report (Table 23) but remains an area where more detailed survey information is required.

Table 28. Annual Sown Forage Legume Trial ARI Sariab (Quetta) - SPRING SOWING 1987

ENT NO.	NAME	ACC. NO.	SEL. NO.	DAYS TO 50% FLOWERING	TDM (KG/HA)	SEED YIELD (KG/HA)
1	VICIA SATIVA	384	2062	87 cd	2125 cde	538 cdef
2	VICIA SATIVA	2	1134	86 de	2102 cde	618 abcde
3	VICIA SATIVA	707	---	83 ef	2250 bc	762 abc
4	VICIA SATIVA	7	1135	85 de	1625 cde	332 fgh
5	VICIA SATIVA	507	2017	86 de	2758 ab	477 def
6	VICIA SATIVA	1652	2086	90 bc	2000 cde	167 h
7	VICIA SATIVA	716	---	85 de	1717 cde	681 abcde
8	VICIA SATIVA	1416	---	93 ab	1250 e	173 gh
9	VICIA SATIVA	1486	2107	95 a	2083 cde	437 efg
10	VICIA SATIVA	2541	LOCAL	84 e	2167 bcd	833 ab
11	VICIA ERVILLIA	2542	---	80 fg	2208 bcd	824 ab
12	VICIA NARBONENSIS	67	---	83 ef	1417 cde	556 bcdef
13	VICIA DASYCARPA	683	---	85 de	3433 a	851 a
14	LATHYRUS SATIVAS	347	---	77 gh	1717 cde	677 abcde
15	LATHYRUS OCHRUS	83	384	82 ef	1333 de	433 efg
16	LATHYRUS SATIVAS	3	311	74 h	1792 cde	721 abcd
COEFFICIENT OF VARIATION				2.45%	22.12%	25.41%
STANDARD ERROR				1.2	260.05	83.46

NOTE:- Means followed by different letters are significantly different at the 0.05 level as indicated by "Duncan's New Multiple Range Tests".

RANGE/LIVESTOCK MANAGEMENT

INTRODUCTION

The importance of small ruminant production on the natural rangelands of Baluchistan has been presented previously in the farming systems section of this report (Tables 3, 4, 5 and 6). However, as this is the dryland agricultural activity of principal importance in the province it is appropriate to emphasize a few points. Small ruminants (sheep and goats) account for approximately 91 % of all domestic animals in Baluchistan (excluding poultry). The Government of Pakistan estimates that 80 % of the population of Baluchistan depends wholly or partly on livestock for their livelihood. Since 1955 there has been approximately a sixfold increase in the number of sheep and goats. At present the total of both species is around 13 million head (Nagy, 1988). It is evident therefore that rangeland grazing resources have come under much increased pressure in the last 30 years.

The research program of the range-livestock management group at AZRI is designed to examine whether there is scope for improvement in the present management of range and livestock resources in Baluchistan. The two principal research sites in current use are Tomagh near Loralai and Zarchi near Kalat (Figure 1).

RESULTS

Grazing Studies

Zarchi range-livestock research station is located 20 km west of Kalat at an elevation of 1800m. The mean annual precipitation at Zarchi is approximately 200 mm, 90% of which occurs in the winter-early spring period. The site was provided to AZRI by a private landowner who controls at least 4,000 ha of rangeland which is available to AZRI for research and development studies. Zarchi was selected to replace, in part, the loss of secure access to the 18,000 ha Maslakh range area, which is nominally under the control of AZRI. It is hoped that the establishment of a research facility of this type on privately-controlled rangeland will enable AZRI to study critical range-livestock production problems, and demonstrate practical measures to improve productivity, under conditions that will translate readily to wider application in the *Artemisia* shrub-steppe region of Baluchistan.

Tomagh range-livestock research station is situated on the Tomagh State Forest 15 km west of Sanjawi in Loralai District. Elevation at the station headquarters is 1800 m, but most of the 4,000 ha state forest available for research is up to 500 m higher. The mean annual precipitation at Tomagh is estimated to be 300 mm, which is distributed approximately 60% and 40% between winter and summer periods, respectively. The Tomagh area provides a greater variety of range types and a richer flora than does Zarchi. The grasslands and grass understory components in the Tomagh range vegetation are of great value to the local livestock economy, whereas the contribution of grasses to the forage resources of the Zarchi area is rather small, under present range conditions. Most of the mountain vegetation at Tomagh would be classified as mixed woodland-grassland, or shrubland-grassland, while the lower elevation plains vegetation is essentially a grassland with minor shrub constituents.

Vegetation sampling at Zarchi and Tomagh field research stations provided estimates of the plant cover, browsable shrub forage, and species frequency on the various study areas. The range vegetation at Zarchi is dominated by *Artemisia intermedia* and *Haloxylon griffithii*. Total shrub cover was estimated to be 10-15%. *Artemisia intermedia* is the key range plant in the Zarchi area, where it produces approximately 75% of the sustainable forage yield. The aggregate range forage available provides an estimated carrying capacity of one sheep unit (0.2 Animal Unit) per 10-15 hectares, on a sustained yield basis.

Data from the kind-of-livestock grazing study, in a mixed shrubland-grassland range type at Tomagh, indicates the following: Woody species make up slightly more than 50%, and two perennial grasses, Cymbopogon jawarancusa and Chrysopogon aucheri, slightly less than 50% of the total forage biomass in the plant community. The former grass species dominates the latter species in biomass by a ratio of 4:1. Three woody species, Prunus persica, Ebenus stellatus and Ephedra intermedia, make up almost two-thirds of the shrub-tree component in this vegetational type. Olea cuspidata was not a major species in the samples, but remains of interest in monitoring vegetation responses, because of its high palatability to goats and its ecological importance in this woodland zone.

One cycle of a high intensity short duration grazing study was started in July at AZRI. Plant cover, plant heights, species frequency, and oven-dry weights of foliage were sampled in six pastures prior to the start of grazing. Sheep used in the study were weighed before and after the initial grazing cycle, in which each of six blocks were grazed by the flock for five days. Approximately 80 % utilization of all grazable forage was obtained by the end of each five-day intensive grazing period. Unfortunately, the severe drought conditions during the summer of 1987 delayed recovery of range vegetation; however, autumn resampling may be feasible. Preliminary observations suggest that the shrub-steppe vegetation in this part of Baluchistan has substantial capacity for recovery from heavy utilization if sufficient length of deferment and an adequate amount of precipitation occur between grazing periods.

Experience gained from the first year's efforts in establishing grazing studies includes realization of how the chronic problem of land control can seriously affect our range research program. The problem of trespass onto designated study areas by local herders and flocks poses a critical threat to maintenance of acceptable experimental control. Trespass has occurred on both state-controlled and privately-controlled land which was provided to AZRI for range research. Despite the employment of full-time herders and guards by the project at both field stations, it has become clear that it is not realistic to expect AZRI staff to maintain control of grazing land used for research purposes. No meaningful evaluation of vegetation responses to grazing treatments can be expected unless exclusion of non-research livestock can be assured. Control of outside animals has not been achieved on the kind-of-livestock study area at Tomagh or on most of the areas under grazing studies at Zarchi.

The problem of lack of land control can be mitigated by a change in orientation of the research and basic experimental designs from "active" to "passive" grazing studies, i.e., from ones in which the researcher controls both land and animals ("active"), to ones in which, for example, controlled land plots are located on areas grazed by animals which are not under the researcher's direct control ("passive"). The season-of-use experiment established last year at Tomagh is an example of a "passive" grazing study, in which the local livestock are permitted to graze the open plots, or are excluded from closed plots, without any direct herder control by the researcher. The researcher in this case merely controls the configuration of the exclosure block to obtain vegetation responses from ambient grazing pressure, hence the approach is "passive". The controlled plots are, in effect, "passive" relative to the active grazing practices of the local herders. Any requirements for the researcher to herd animals, or control large areas of land, as critical elements of a grazing study, are thereby eliminated. The design of "passive" vs. "active" grazing studies has its own limitations, and is not without demands on plot maintenance and control, but this approach could help to solve the general and persistent problem of grazing land control, as these factors affect our research program.

Livestock Management and Nutrition Studies

Study of the relationships between nutritional status and productivity in sheep has a high priority in the current research program. An experiment involving 90 Harnai ewes at Tomagh and 90 Baluchi ewes at Zarchi was started in September 1987. This experiment compares the effects of nutritional levels of ewes, prior to the breeding season and during late gestation, on lambing percentages and other production parameters. Livestock inventories at all three stations were adjusted to accommodate this and other ongoing livestock management studies.

An earlier study investigated the effect of feed supplementation on liveweight gain of ewes grazing cereal crop residues. Fifty-two Baluchi ewes were divided randomly into four groups of 13 animals each. All animals were grazed together on cereal crop residues for eight hours each day, and were then removed from pasture. The control group (A) was provided with no additional feed. Animals in the treatment groups were supplemented individually with 350 g/day of barley grain (Group B), 100 g/ day of cottonseed cake (Group C) or 175 g/day barley grain plus 50 g/day cottonseed cake (Group D). Supplementation levels were designed to provide approximately equal quantities of nitrogen in the supplemental ration. None of the supplemental feed was refused during the experimental period of 60 days. Liveweight gains for the four groups are shown in Table 29.

Table 29. Liveweight gains of ewes fed supplemental rations.

	A	B	C	D
Treatment	Control	Barley Grain	Cottonseed Cake	B+C
Liveweight	28.8	53.0*	42.6	52.8*

* significantly different from control value ($P<0.05$)

Treatments B and D resulted in significant increases in liveweight gain (Duncan's Multiple Range test, $P<0.05$). Liveweight response to treatment C (cottonseed cake alone) approached but did reach not significance.

Animals supplemented with barley grain gained an additional 24.2 g/day as compared to the controls. Those provided with the mixed supplement outperformed the control group by 24.0 g/day. The barley grain supplement cost Rs.1.75/kg and the cottonseed cake cost Rs.2.40/kg. The cost of supplementation was Rs.0.61/day for treatment B and Rs.0.43/day for treatment D. Thus, the extra weight gain resulting from supplementation was realized at a feed cost of Rs.25.7/kg liveweight from barley grain and Rs.17.8/kg from the mixed supplement. The estimated price of slaughter sheep in Quetta area in late 1987 was Rs.20.00/kg. Under these marginal return/marginal feed cost conditions the results of this study suggest that some form of supplementation could be economically feasible. More information is needed on animal responses and economic factors related to supplementation before any firm conclusions can be drawn.

As the reporting year ended, the AZRI laboratory facilities for conducting animal nutrition and health research were still not operational. Essential work involving forage values of range plants and other feedstuffs; diet analyses; feed digestibility; and livestock parasites has had to be deferred under present conditions. Staff development has progressed and will continue, with emphasis on specialized training as needed. However, a significant expansion of research work in livestock nutrition and health, including some critically needed coordination with other aspects of the range-livestock program, will necessarily await further development and installation of laboratory facilities. These are expected to be operational by the end of 1987.

Range Rehabilitation Studies

Major attention has been focused during the past year on the testing of perennial grasses for reseeding depleted rangelands, and the development of a forage shrub nursery and transplanting program. Results from early spring range plant adaptability trials indicate that there are a number of commercially available range grasses that could be used successfully to reseed marginal croplands or degraded rangelands in upland Baluchistan. Further field plot testing in the current season might lead to firm recommendations for large-scale seeding trials in the following season.

Nurseries for the production of fourwing saltbush (Atriplex canescens) seedlings were established at AZRI (Quetta), Zarchi and Tomagh. More than 300 seedlings, in tubes, were set out at Tomagh in two separate adaptability/persistency experiments, and about 400 tube-established seedlings were transplanted at Zarchi to test adaptability/persistency and to establish a shrub forage reserve. Four hundred additional seedlings of fourwing saltbush were available at the start of the autumn planting season. This will be used in proposed farmer-managed trials to test the feasibility of establishing village forage reserves with this valuable shrub.

Destructive sampling of fourwing saltbush forage production conducted at AZRI suggests that this salt- and drought-tolerant desert shrub could yield 2000 kg/ha per annum, or more, of nutritious feed for sheep, goats, camels and other livestock from rangelands with only about 25 % cover of this species. Further study of fourwing saltbush productivity, palatability, forage value, germination characteristics and transplanting requirements will be a priority research area in the 1987-88 growing season. Other forage shrubs with similar ecological and nutritional values will also be examined and, if possible, added to the nursery and transplanting program which is planned for expansion.

Botanical Support and Facilities Development

Plant collections and identification of species continued with the further development of the AZRI herbarium. Rainfall records were started at Tomagh and Zarchi. Improvements were made to barns, sheds, fencing and water systems at all three sites where research livestock are maintained. Four new range exclosures were established, at or near Tomagh, to provide long-term monitoring of vegetation changes and estimates of range productivity.

AGRICULTURAL EXTENSION

INTRODUCTION

Agricultural extension for dryland farming and livestock management in upland Baluchistan is a discipline in which little research has been undertaken in the past. The agricultural communities are essentially under tribal organization and communication infrastructure (roads, telephones, transport, etc.) is, at present, only at the beginning of the development process. In upland Baluchistan at least four major languages are spoken within the different tribal and urban communities: Urdu, Baluchi, Brahui and Pashto. Naturally this substantially increases the problems of dissemination of agricultural information. These problems are further enhanced by not insignificant levels of illiteracy among the rural male and female population. In addition, the density of the rural population is very low and transhumance is a common practice. This makes regular contact with farmers exceedingly difficult. The Provincial Department of Agriculture in Baluchistan has a network of extension officers. Their role at present places a major emphasis on irrigated agriculture. Extension services per se for livestock and rangeland management do not formally exist. However, some infrastructure through veterinary officers and officials of the Forestry Department is in operation.

The policy of the extension/communication research group at AZRI has been to assist, where possible, existing extension services in Baluchistan and to actively involve them in AZRI's research program. The intention is to stimulate personal interest in jointly evolved technological innovations by AZRI and provincial extension agencies and thereby ensure commitment to their wider dissemination in rural Baluchistan. In addition, the extension/communication group is attempting to pinpoint the major constraints to extension in the province and to examine whatever communication patterns are common in rural communities. It is hoped, that enhanced understanding of communication patterns, will improve extension methodologies developed in association with mass media agencies and provincial extension services.

RESULTS

FARMER MANAGED TRIALS

A series of farmer managed trials were initiated in the spring of 1987 with the following objectives:

1. Test the results of the scientist managed agronomy trials under farmer managed conditions;

2. Obtain good quality data on the labour requirement of farm operations to facilitate economic analysis of these farmer managed trials and the scientist managed agronomy trials;

3. Evaluate farmers technical abilities;

4. To provide a vehicle for close contacts with farmers, to examine constraints to extension; and to involve cooperating provincial government extension agencies in AZRI's research process.

A simple trial comparing the productivity of the local wheat cultivar and an "improved" cultivar, Blue Silver, with and without phosphate fertilizer (60 kg/ha P_2O_5 as triple super phosphate, sown into the seedbed with the seed) was initiated in spring 1987 in Kovak valley (Figure 1). The "improved" variety Blue Silver was chosen as suitable for spring planting. Twenty farmers participated in the trial, sowing the four treatments as a single replicate into individual quarters of the field selected by the farmers for the experiment. Four samples were taken in each treatment for yield estimation, the rest of the crops were harvested by the farmers for their own purposes.

Results are shown in Table 30. Averaged over all locations and both varieties phosphate fertilizer increased grain yields by 21%. The improved variety consistently outyielded the local variety in this spring planting trial and showed a much higher response to phosphate, with an overall increase of 31% increase in grain yield. Straw yields were unaffected by fertilizer or by variety.

Table 30. Grain and straw yields (kg/ha dry weight) of farmer managed trials, Kovak 1987 (spring planting). Results of 20 farmer's fields analysed as CRD with each site treated as a replicate.

	Grain yields (kg/ha)		
	Local	Blue Silver	Mean
- phosphate fertilizer	304	348	326
+ phosphate fertilizer	329	478	403
Mean	316	413	365
S.E.	24.0	24.0	17.0
Probability	NS	<0.1%	<0.1%

	Straw yields (kg/ha)		
	Local	Blue Silver	Mean
- phosphate fertilizer	923	907	915
+ phosphate fertilizer	929	927	928
Mean	926	917	922
S.E.	56.1	56.1	39.7
Probability	NS	NS	NS

ECONOMIC ANALYSIS

Five of the twenty cooperative farmers were closely monitored to obtain labour data on the time that it took to plant and apply fertilizer on the two fertilizer treatment plots versus the labour time of planting alone in the traditional manner. The data in Table 31 (on a per hectare basis) indicates that applying fertilizer with the seed did take marginally longer than planting in the traditional manner. Traditional planting required 12.42 hours/ha while planting with seed and fertilizer mixed required on average 13.58 hours/ha a difference of 1.16 hours/ha.

Calculating the opportunity cost of the additional labour for fertilizer application is difficult. Assuming the opportunity cost of labour is Rs.20/day for an 8 hour day, the hourly cost is then Rs.2.5 which makes the additional labor cost for fertilizer application a total of Rs.2.9/ha. In addition to the application, mixing the seed and fertilizer prior to planting takes about an hour.

Several fertilizer outlets were surveyed to obtain the price of Triple Super Phosphate (0-46-0). The average market price for a 50 kg bag was Rs.95 in January, 1987, the period in which farmers would have bought the fertilizer. Average transportation charges from the market to the farm gate total Rs.2.5 per 50 kg bag, thus costing the farmer Rs.97.5 for a 50 kg bag of fertilizer. The application rate was 60 kgs P_2O_5/ha, thus the total cost for fertilizer/ha is Rs.253.5 (Rs.97.5/bag x 60/23 bags).

The post harvest farm gate wheat price from a survey of farmers in the Kovak area was on average Rs2/kg.

Table 31. Cooperative farmer labour data, Kovak.

	Cooperative Farmer					Average
	1	2	3	4	5	
	Hours/ha					
Traditional Planting	10.42	12.50	14.58	10.42	14.17	12.42
Planting + Fertilizer	12.08	13.33	16.25	10.83	15.42	13.58
Difference	1.66	0.83	1.67	0.41	1.25	1.16

The analysis of variance results indicated that there was no significant difference in straw yields between treatments. Thus the economic analysis is based on grain yields only.

Variety Treatment Comparisons: On average, Blue Silver produced 44 kg/ha more than the local variety and resulted in a net revenue gain of Rs. 88/ha (Table 32). No additional labour or costs were involved in this treatment. Seventy percent of the twenty cooperating farmers obtained a higher yield with Blue Silver than with the local variety in the trials. It should be noted that these results refer to spring planting only.

Fertilizer Treatment - Comparisons with Control: To pay for the fertilizer cost of Rs.253.5/ha, the farmer requires an additional 127 kg of wheat grain at the selling price of Rs.2/kg. On average, the breakeven point is 304 kg/ha (the control), plus 127 kg/ha for a total of 431 kg/ha which represents the yield the farmer would have to get before fertilizer application would pay. Any yield less than 431 kg/ha in each of the two treatments that include fertilizer would mean that the farmer would be better off not applying fertilizer. The economic analysis in Table 32 indicates that applying fertilizer to the Local White wheat variety increased yield over the Control by only 25 kg/ha and not by the required 127 kg/ha. The addition of fertilizer to Blue Silver however, increased yield over the Control by 174 kg/ha and is therefore a profitable alternative to the Control. The return per hour of additional labour for this treatment is Rs. 44 and is substantially above the Rs. 2.9/hr opportunity cost of labour. On an individual basis, with the local variety, only 15% of the cooperative farmers covered their fertilizer cash costs with revenue from the yield gain above the Control. Whereas, with the improved variety 65% covered their fertilizer cash costs with the revenue from the yield gain.

Blue Silver with and without Fertilizer Comparisons: The yield gain resulting from the addition of phosphate fertilizer to Blue Silver of 130 kg/ha (Table 32) is 3 kgs above the required gain of 127 kg/ha to cover the fertilizer costs. The net revenue gain is Rs. 6 when averaged over all twenty farmers. On an individual farmer basis, half of the farmers had a yield large enough to cover the fertilizer cash costs with revenue from the yield gain above the yield of Blue Silver without fertilizer.

Table 32. Economic Analysis of the Farmer-Managed Trial, Kovak, 1987

	Treatments[1]			
	LW	LW,F	BS	BS,F
Grain Yield, Kg/ha	304	329	348	478
Yield Gain Above Control, Kg/ha	-	25	44	174
Net Revenue Gain Above Control,Rs.[2]	-	-203	88	95
Return/hr. of Additional Labor,Rs.[3]	-	0	-	44
Yield Gain Above BS, Kg/ha	-	-	-	130
Net Revenue Gain Above BS, Rs.[2]	-	-	-	6
% Farmers Covering Cash Costs[4]	-	15%	-	65%
% Farmers BS Yield > Control[5]			70%	

[1] LW = Local White variety which is the Control; BS = Blue Silver variety; F = 60 kg/ha 0-46-0 mixed in with the seed. Yield data from twenty cooperative farmers.
[2] Net revenue gain = yield gain x grain price (Rs. 2/Kg) minus fertilizer cost of Rs. 253.5/ha (Rs. 97.5/50 kg bag which includes Rs. 2.5/bag transport cost).
[3] Net revenue gain/additional labour required (1.0 hours/ha for fertilizer preparation plus 1.16 hours/ha for application.
[4] The percentage of cooperative farmers in the trial who would have been able to pay for the cost of fertilizer with the revenue from the yield gain above the control.
[5] The percentage of farmers who obtained a higher yield with Blue Silver than with the Local White variety.

Table 33. Risk Analysis of the Farmer-Managed Trial, Kovak, 1987[1]

Treatment[2]	Mean Net Benefit	Std. Dev.	Index of Var.[3]	Lowest Net Benefit	Average of Lowest 2 NB's
LW	608	211	34.8	108	226
LW,F	404	228	56.4	-42	-5
BS	696	207	29.7	274	338
BS,F	702	212	30.2	285	388

[1] MSTAT ECON Program.
[2] LW = Local White variety which is the Control; BS = Blue Silver variety; F = 60 kg/ha P_2O_5 as 0-46-0 fertilizer mixed in with the seed. Net Benefit data from twenty cooperative farmers.
[3] Index of variability = (Std. Dev./Mean Net Benefit) x 100.

Risk Analysis.

Table 33 shows a risk analysis for the farmer-managed trial. MSTAT risk analysis pools the within-site replications over years and considers the average yields of each treatment representative of the site-to-site, year-to-year and management variability in yields. Since the farmer managed trial has been conducted for only one year, information in Table 33 only represents site-to-site and management variability in yields. Year-to-year variation, which is the more important risk information, will be analyzed as data is made available from the farmer managed trials in the coming year. Treatments that have high net benefits with low standard deviations are preferred. This is signified by a low index of variability which is computed as follows: (Std. Dev./Mean Net Benefit) x 100. Also presented in Table 33 is the lowest net benefit for each treatment and also the average of the lowest two net benefits.

Applying fertilizer to the local variety has a high index of variation and net benefits that are negative. It is therefore a risky alternative relative to the remaining three treatments. The index of variability of the Blue Silver treatments are slightly lower than the local variety which suggests that these two treatments are no more risky than the local. The Blue Silver treatment has the second highest net benefit and the lowest Std. Dev. with the lowest Index of Variability.

Sensitivity Analysis

Changes in prices and costs may change the relative rankings of the treatments (see Table 33 for treatment abbreviations).

<u>Changes in the fertilizer price</u>. A small increase in the fertilizer price holding wheat prices at Rs. 200/100kg would make treatment BS more dominant. A fertilizer price rise of Rs. 37 /50 kg bag (a 38% increase over Rs. 97.5/50kg bag) would be

required to make the net benefit of treatment BS,F equal to that of the control. A decrease in the fertilizer price would make treatment BS,F more dominant. It would however require a fertilizer price as low as Rs. 19.2 /50 kg bag before treatment LW,F would have a net benefit equal to that of the Control.

Changes in the wheat price. An increase in the Rs. 200/100kg wheat price holding the fertilizer price at Rs. 97.5/50 kg bag would make treatments BS and BS,F more dominant. It would however require a wheat price of Rs. 1000/100kg before treatment LW,F would have a net benefit equal to that of the Control. A decrease in the price of wheat to Rs. 145.6/100kg would make the net benefit of treatment BS,F equal to that of the Control. A decrease in the wheat price to Rs. 195/100kg would make the net benefit from treatment BS,F equal to that of treatment BS.

The sensitivity analysis shows that small changes in the wheat and fertilizer prices would change the relative dominance of the BS and BS,F treatments.

Based on one year's field data, the lower net benefits and higher index of variability of treatment LW,F relative to the Control indicate that this treatment would not be adopted by farmers. The two treatments of BS and BS,F have moderately higher net benefits and lower index of variation coefficients than the Control and with further testing, make these possible candidates for recommendation. There is little to choose from between treatments BS and BS,F. However, given that Blue Silver seed is available, treatment BS would probably be adopted before treatment BS,F. Treatment BS has no additional labour or cash costs and is a less complex intervention.

The collection and economic evaluation of the agronomic data is only one aspect of this trial. Observations of farmer behaviour and their opinions were collected regularly. The key factor of this process is to gain the farmers' confidence and ensure a frank interchange of information. It would appear that the cooperating farmers were enthusiastic about the trial and provided better quality land than the average available on their farm. This creates a small bias in the results, but it is preferable to the attitude of "accept free seed and plant it on poor land without caring about the outcome" which can be an alternative where farmer-researcher relations are poor.

We have learned from this year's trial that a strict supervision of experimental conditions eg. of seed rate may not be the most appropriate methodology. In future years we may adopt a more flexible approach with farmers modifying the technological innovations under trial in accordance with their individual circumstances.

It is also evident that there is a need to invest more time in fostering interest and cooperation with the local extension services. This may not only involve the locally based agent but also include members of the Quetta based Adaptive Research and Extension Project team. These members of the Extension Department are largely involved with irrigated agriculture but have shown a willingness and interest to be involved in AZRI sponsored activities.

Cooperative Farmer Survey

Table 34 presents information and data obtained from a questionnaire given to the twenty cooperative farmers in Kovak who participated in the farmer-managed trials. The prime objective of the questionnaire was to obtain comments from farmers about the technologies being tested in their fields and to gather background information.

One-half of the cooperative farmers planted wheat in their fields in the Jan-Feb period which made up 25 percent of their total 1986-87 wheat plantings. Ninety-five percent said that the wheat planted in the Autumn (1986) out-yielded the wheat planted in the Jan-Feb (1987) period. Farmers have planted wheat in the Jan-Feb period in 4 to 5 years out of the past ten years. Their major reason for planting in the Jan-Feb period is insufficient rainfall in Autumn.

Farmers took a keen interest in the trials and 95% could name and readily discuss the four treatments. The farmers were able to rank the treatments with respect to yield in their own fields. Their rankings corresponded with the ANOVA of the yield data. Seventy percent of the farmers said that if it would have rained less, the Blue Silver-fertilizer treatment would still have been the best. Thirty percent of the farmers responded with the remaining three treatments. Ninety percent said that the Blue Silver-fertilizer treatment out-yielded their own Jan-Feb planted wheat.

In response to whether farmers would like to use Blue Silver next year, 95% said yes. However, only 35% of the farmers said that they would use fertilizer next year. Their first reasons for not using fertilizer was its availability and transport problems and the cash (credit) requirements to purchase the fertilizer. Ninety-five percent of the farmers said that they thought that it would pay to use fertilizer on the Blue Silver-fertilizer treatment whereas 85% said that the Local White-fertilizer treatment would also pay. However, the economic analysis (Table 32) indicted that farmers would have been better off with planting Local White alone than planting Local White with fertilizer.

Farmers indicated that it took more time to plant the fertilizer-seed treatments than with seed alone which is borne out by Table 31. Only two farmers said that they had a problem with sowing the mixture of fertilizer and seed in the fertilizer-seed treatments.

To show further cooperation with the farmers, threshing machines were made available to harvest the experiments as well as some of the farmers grain.

Ninety percent of the farmers said that it was the first time that they had used a threshing machine on their own land and 45% said that it was the first time that they had seen one operate. Thirty-five percent of the farmers said that they would rent a threshing machine at cost for next year's harvest. The reasons for not renting a threshing machine by the remaining respondents was the high cost.

In summary, farmers were clearly aware that Blue Silver and Blue Silver with fertilizer increased yields above that of the traditionally used Local White variety. Their responses indicated that they were not fully aware of the economics involved in using fertilizer. This is perhaps due to that fact that they did not actually purchase the fertilizer for the experiments with their own money as it was provided by the extension group.

Table 34. Selected information from Cooperative farmers survey, Kovak, 1987.

Farmer Profile, Land and Animal Resources			
Average Age	46		Range 30-70
Can read and write	10%		
Private ownership of arable land	90%		
Average Kushkaba land owned	47	acres	Range 2-150
Sailaba land owned	10	acres	One farmer
Average Kushkaba land rented in	22	acres	14 Farmers
Average Kushkaba land rented out	14	acres	6 Farmers
Average Livestock Numbers			
Camels	2.0		Range 0-7
Sheep	30.8		Range 0-200
Goats	30.2		Range 0-150

Information on Autumn Versus Jan-Feb Planting	
Farmers who planted wheat in Jan-Feb, 1987	50%
Proportion of Jan-Feb to autumn wheat planted, 1987	25%
1986 autumn planted wheat out-yield Jan-Feb wheat?	95% yes
Number of yrs in past ten farmers planted in Jan-Feb	4-5 yrs
Farmer Awareness and Assessment of Introduced Technology	
Could farmers name and discuss the four treatments	95% Yes
Selected Blue Silver-fertilizer treatment as best	100%
Will farmers use Blue Silver next year	95% Yes
Will farmers use fertilizer next year	35% Yes
Did it pay to fertilize the Blue Silver treatment	95% Yes
Did it pay to fertilize the Local White treatment	85% Yes
Did the fertilizer treatments take more time to sow	100% Yes
Had problems sowing mixture of fertilizer and seed	10% Yes
Threshing Machine Information	
Threshing machine used for first time this year	90% Yes
Farmers who saw threshing machine operate first time	45% Yes
Was the grain broken by the threshing machine	25% Yes
Was the straw quality as good as threshing by animal	90% Yes
Will you rent a threshing machine at cost next year	35% Yes

Survey by AZRI/farming systems and extension groups of twenty cooperative farmers who participated in the farmer-managed trials at Kovak.

VETERINARY CAMP AT KOVAK

A temporary veterinary camp was organized jointly by the Livestock Department (Government of Baluchistan) and AZRI at Kovak on April 8-9, 1987. This was one of a wide-ranging series of veterinary camps organized by the Provincial Livestock Department, but was the first of this type in Kovak valley. Livestock is the main source of family income and human food in the Kovak valley. Sheep and goats are the dominant forms of livestock, totalling number is around 27,000 head. Almost all families have a small number of poultry which are used for family consumption. Camels are used as draft animals.

In Table 35 the numbers of animals treated are presented for treatments against the three major animal health constraints: enterotoxaemia, anthrax and internal parasites. The impact of this intervention will be assessed in the Kovak valley over the next two years. However, the implications for successful livestock extension activities were clearly noted and include the chance for "face to face" training for farmers with Livestock Department officers, and an opportunity for large scale farmers' exposure to audio-visual training materials.

Table 35. Treatments administrated at temporary veterinary camp in Kovak valley on April 8 and 9, 1987.

Treatment	Sheep & Goat	Camel
Vaccination Enterotoxaemia	5,757	Nil
Vaccination Anthrax Spore	6,202	43
Dosing Liverfluke & Worms	6,202	43
Castration	10	Nil
TOTAL	18,171	86

COMMUNITY PROFILE AND EXTENSION SURVEY

A formal survey is presently underway (October 1987) in a number of areas in upland Baluchistan. It is designed to highlight the most significant aspects of village organization and communication patterns. Resulting information will assist in the development of effective extension methodologies appropriate to rural communities. It is also expected that a better understanding of local cultural contexts will enable easier implementation of an extension program. In addition, information on literacy, access to communication media and current contacts with existing extension programs is being collected. This will supplement the database obtained from the Household Agricultural Production Systems Survey conducted in early summer 1987 (not yet reported).

1987 - 88 SEASON PLANNING MEETING REPORT

The Planning Meeting of the MART/AZR project for the 1987-88 cropping season was held at AZRI on the 3rd and 4th June 1987. It was attended by representatives of PARC, USAID, ICARDA, the Provincial Livestock Dept., the Provincial Agricultural Research Institute, Sariab, Chief Conservator of Forests Office, AZRI and MART/AZR.

On Wednesday, 3 June, field locations of the Germplasm group (ARI Sariab), Agronomy group (Dasht), Extension/Farming Systems/Agronomy groups (Kovak) and Range-Livestock group (Zarchi) were visited with a view to familiarizing non-local participants with the environment of Baluchistan and with a cross section of MART/AZR field activities.

On Thursday, 4 June, a full day of planning discussions took place. The draft workplan of each of AZRI's five research groups for the 1987-88 season was presented in the light of the present and previous season's results (available from MART/AZR, P.O.Box 362, Quetta). The main discussion points raised are summarized below.

1. Risk

Throughout the discussions of all groups, an emphasis was placed on the inter- and intra-year variability and unpredictability of rainfall and on the production risk involved in the dryland farming systems of Baluchistan. The criteria for technology evaluation in the farming system group workplan included production risk. Several people agreed with the need to include risk in technology evaluation. Questions were asked about how risk was going to be incorporated in technology evaluation.

The response given was that, although theory on risk is rich, it is difficult to make it operational because of data, information and methodology deficiencies. Many of the methodologies involve obtaining a yield variance for which data is available, i.e., for traditional farming practices. However, technological interventions do not have a history and this information is therefore not available. Information from the on-farm researcher managed and from farmer-managed trials will be used for this purpose, even though the data is not complete. Information on risk in its simplest form can be used, such as calculating the percentage of farmers who would have lost cash (yield), from using the technological intervention in the farmer-managed trials. More complicated methods can be used within a mathematical programming (quadratic programming) framework. Using an E-V (mean - variance) analysis, trade offs between the increased income generated from a technology intervention and the probability (risk) of obtaining the increased income can be calculated. The methodology that ultimately will be used has not been decided. This will depend on the quality of the information coming from the on-farm trials and formal survey information as well as on the ability of AZRI staff to construct mathematical programming models.

2. Mathematical Programming

There was some discussion on linear programming (LP). Since few people were familiar with the technique, it was further explained and the reasons for its use reiterated as spelled out in the farming systems workplan. There was concern that LP may be too data demanding and sophisticated a technique for AZRI to use. Some of the data already exists from the 1986 agronomy survey and further data and information will be forthcoming from the formal survey presently being conducted (July 1987). LP is not a new technique and the farming systems group staff have had a limited exposure at the M.Sc. level. It is also one of the few techniques available beyond that of simple budgeting for technology evaluation, given the limited adoption of technology in Baluchistan. Dr. E. Thomson, PFLP ICARDA/Aleppo, who has experience with LP, encouraged its development.

3. Potential Expansion of Barley Hectarage

Less than ten thousand hectares of barley are regularly grown in Baluchistan under dryland conditions. The local cultivar appears to be quite well adapted to local environmental conditions and the explanation as to why it is not grown more widely is unclear. At present breadwheat, the subsistence food crop, takes an overwhelming priority. Nevertheless, the potential for an expansion of barley hectarage for use as supplemental feed for small ruminants appears to be very large.

4. Reduction in Emphasis on Wheat Research in the Germplasm Group

It was explained that although the emphasis on wheat in general was being reduced, largely by the omission of durum nurseries, the germplasm group was still committed to finding a series of breadwheat cultivars suitably adapted to the colder and drier areas of Baluchistan. Complete omission of all durum wheat research was suggested as a possibility due to its sensitivity to frost and to no proven demand or market to date.

5. Perennial Forage Legume Research

This was raised as an issue during the Range-Livestock presentation, but initial work has already been established by the germplasm evaluation group. The issue of the introduction of perennial plant species is seen as a joint range/germplasm group effort. (See point 10)

6. Plot Levelling

The issue of inadequate levelling of farmers' fields was raised as a potential constraint to productivity in farmers' fields and agronomy group experimental areas. This was recognized by the agronomy group who also emphasized the need for better seed - bed preparation which is associated with this issue. More attention will be paid to these details in the following seasons.

7. N. Fertilizer

The lack of response to N. fertilizer application in 1985/86 was raised as an issue. The agronomist stated that a lack of response to N. is frequently found in arid areas, but continuing to evaluate this response over a three to four year period was necessary to draw firm conclusions. These experiments are in progress.

8. Intercropping and Early Planting of Forage Crops
It was suggested that early planting of forage crops (Barley and *Vicia* species) with or without intercropping should be considered. This is incorporated in next season's workplan.

9. Forage, Fuel, and Shade Trees and Shrubs for Rangelands
Several participants recommended greater emphasis on testing and introduction of woody species to satisfy the specific needs of pastoral people and their livestock. The discussion included the impacts of fuelwood harvesting and livestock overgrazing associated with concentrations of Afghan refugees in Baluchistan. Comments included the need for recommendations regarding range rehabilitation plants and practices, including the establishment of forage, fuel and shade trees.

10. Perennial Range Grasses and Legumes
Comments by participants emphasized the need for adapted perennial grasses and legumes to improve seasonal distribution of range forage. Expanded testing of promising species received support.

11. Annual Production Phases as Related to Nutritional Status of Animals
Continued emphasis on the relationship between range forage and the three major phases in the production cycle, i.e., conception, gestation, and lactation would be evaluated. Studies were recommended to investigate the fertility factor and lactation management, especially aimed at strategies for achieving the full genetic potentials of local animals.

12. Increased Meat Production from small ruminants was recommended to receive priority over wool production; but the latter topic is not to be ignored.

13. Camel Research was strongly recommended as a legitimate part of the AZRI range-livestock program.

14. Farmer Managed Trials
Support for a wider expansion of these efforts was received as indicated in the draft workplan. The need for careful selection of appropriate technological interventions was stressed.

15. Resource Center Development
Increased concentration of effort in the next two years was recommended to ensure development of this important research resource.

The substance of these 15 points has, or will be, incorporated in the workplans for 1987-88.

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