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HIGH-ELEVATION RESEARCH IN PAKISTAN: THE MART/AZR PROJECT

Annual Report for 1989

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HIGH-ELEVATION RESEARCH IN PAKISTAN:
THE MART/AZR PROJECT

FINAL PROJECT REPORT AND ANNUAL REPORT
FOR 1989

Arid Zone Research Institute, Quetta, Pakistan
and
International Center for Agricultural Research in the Dry Areas
(ICARDA)

HIGH-ELEVATION RESEARCH IN PAKISTAN: THE MART/AZR PROJECT

FINAL PROJECT REPORT AND ANNUAL REPORT FOR 1989

TABLE OF CONTENTS

	PAGE
Introduction	3
Farming Systems/Agricultural Economics	4
Introduction	4
FS/Econ. Research Program	5
Achievements	7
Future Research Directions	18
Training Workshops	19
Publications	19
Range-Livestock Research	22
Introduction	22
Building the R-L Research Program	25
Implementation	25
Training	44
Publications	46
Agronomy	48
Introduction	48
Agrometeorology	49
Water Harvesting	52
Improved Rain-Fed Crop Production	54
Barley and Forage Legumes	56
Future Recommendations for Training	59
Publications	59
Germplasm Evaluation	62
Introduction	62
Research Strategy	63
Climatic Conditions	64
Achievements	66
Comment and Future Directions	72
Publications	75

Agricultural Extension 77
Introduction 77
Field Activities 78
Research in Extension Issues 81
Information Transfer 84
Alternatives for Technology Transfer 86
Workshops 88
Publications 89

Conclusions 90

MART/AZR Project Complete Publication List 91

Dryland Agricultural Research at the Arid Zone Research Institute 1985-1989: Retrospective and Directions for the Future

INTRODUCTION

In 1985 the International Center for Agricultural Research in the Dry Areas (ICARDA) entered into a contract (No. 391-0489-00-C-5042-00) with the United States Agency for International Development (USAID) Mission to Pakistan in order to improve and upgrade the research capability of the Arid Zone Research Institute (AZRI) of the Pakistan Agricultural Research Council (PARC). This contract formed the Arid Zone Research component of USAID's Management of Agricultural Research and Technology project.

Five expatriate research advisers were provided to AZRI, four of whom were from ICARDA and one, the range/livestock adviser, was provided by Colorado State university under a sub-contract to ICARDA. One adviser was allocated to each of AZRI's five research groups: agronomy, germplasm evaluation, range/livestock management, agricultural extension and farming systems/agricultural economics.

This report summarizes the status of research at AZRI at the initiation of the project, research achievements during the life of the project and recommendations for the future direction of research for each of the groups at AZRI. It should be noted that though the project's work is reported in five distinct disciplinary units much of the work was systems oriented and was not limited by disciplinary boundaries.

FARMING SYSTEMS/AGRICULTURAL ECONOMICS

INTRODUCTION

Prior to the arrival of the Farming Systems/Agricultural Economics adviser, the AZRI research group helped the agronomy adviser in an informal survey of the dryland farming systems of upland Baluchistan (MART/AZR Research Report 5) and made a compilation of secondary agricultural statistics that was later expanded and published by the group (MART/AZR Research Report 20). However, prior to the initiation of the MART/AZR project in 1985 AZRI had no staff with training in agricultural economics or farming systems research.

The scope of work for the farming systems specialist with the MART/AZR project as written in the contract is as follows:

1) Assist in undertaking a series of surveys and studies of socio-economic factors that influence farm and livestock management in the dry areas of Pakistan. These studies shall be conducted by AZRI and ARI scientists and University Personnel, and shall include, but shall not be limited to the following topics:

a) agricultural decision-making patterns of the various tribes of Baluchistan;

b) agricultural price policies and structures including factor costs, farmgate and market prices and farmer risk analysis; and

c) diagnostic studies designed to uncover research topics, and ensure that socio-economic variables are included in research design implementation analysis and monitoring impacts.

2) Organize and conduct workshops to train AZRI staff, provincial extension officials and university professors in a range of research and extension methods. Specific topics will relate to the studies undertaken;

3) Develop methods for monitoring and assessing impact of research, diffusion, adoption and resistance to innovations. Implement these methods in association with other expatriate and national scientists;

4) Assist in the selection of candidates and disciplines for long and short-term training; and

5) Supervise graduate student thesis research.

THE FARMING SYSTEMS/ECONOMICS RESEARCH PROGRAM.

Collaborative efforts among the FS/Econ, agronomy, germplasm, range-livestock and extension/communications sections follows a traditional farming systems approach. The approach emphasizes:

1) description and diagnosis of the farming systems,
2) the design of on-farm research,
3) on-farm testing and evaluation, and
4) dissemination and monitoring

(see MART/AZR Research Report No. 8 for further discussion on Farming Systems).

The design of on-farm research for each planting season was a collaborative effort among the groups. Because AZRI research is in its early stages with few interventions in hand, dissemination and monitoring of interventions at this time received less attention. Thus the main program of the FS/Econ group evolved around the two themes of:

(1) description and diagnostics of the farming systems, and

(2) technology evaluation.

1) Descriptive, diagnostic and information gathering activities.

Descriptive and diagnostic informal and formal surveys are carried out at AZRI to (1) describe the current farming systems and (2) to understand the major agricultural production and marketing constraints and priority problems faced by farmers. This information is used by all AZRI researchers in the design of the AZRI research program. A description of how an informal survey is conducted at AZRI is given in MART/AZR Research Report 3. MART/AZR Research Reports No's. 5, 7 and 10 include data and information obtained from formal surveys.

2) Technology evaluation activities.

Technology evaluation involves the following criteria:

(1) technical feasibility in the field (ANOVA),

(2) economic profitability and risk evaluation,

(3) the fit of the technology in the farming systems and,

(4) socio-cultural considerations (See MART/AZR, Research Report 8 for further discussion on evaluation criteria).

Major emphasis is on evaluating the on-farm researcher-managed and farmer-managed field experiments of the agronomy, extension and range-livestock groups. (see ICARDA, 1988 and MART/AZR Research Report 12 for the 1986-87 season economic evaluation results).

To date, the evaluation work at AZRI mainly involved criteria 1 and 2 with some attention to criteria 3 and 4. Criteria 1 involves using some

variation of ANOVA and field site information to determine if new technology treatments are better than the control treatment. Economic profitability and risk analysis (Criteria 2) has been done using partial budget analysis and some risk analysis using the MSTAT program. Labour data analysis, marketing information and farmers comments have been used for criteria 3. One whole farm modeling study was undertaken - an ex-ante economic analysis of sheep interventions (MART/AZR Research Report 35). Criteria 4 has been taken into consideration through the information gathered by the extension/ communication group (MART/AZR Research Report 11) and by some of our survey work.

ACHIEVEMENTS

1. Descriptive and Diagnostic Work

a). Formal Agronomy Survey (1986).

Eighty farmers in four locations in upland Baluchistan were surveyed in May/June, 1986. The data were analyzed in collaboration with the agronomy and extension groups.

The dryland arable farming systems of upland Baluchistan operate under many constraints, principally low and erratic rainfall (annual totals vary from 150 to 300 mm), long periods of low temperatures during winter and soils of low fertility. The probability of summer rains, critical for autumn planting of winter wheat, barley and lentils is as low as 1 in 3 in large areas of upland Baluchistan. Baluchistan dryland farmers classify three to five years out of ten as a poor crop year with very low grain and fodder yields. The farmers have developed a range of water harvesting practices that minimize production risk: ridge/ furrow management of the soil, diversion of seasonal streams onto arable fields, contour earth bunding. Despite this yields remain low and variable: farmers' expectations of wheat and barley grain yields average from 0.4 to 0.1 t/ha.

The high risks of production have militated against the use of available modern inputs: animals remain the main source of power for plowing, planting and threshing; harvesting is done by hand; local varieties of seed are almost exclusively used; fertilizers, herbicides and pesticides are not used; what little weeding is carried out is done by hand. Off-farm sources of income range from 10 to 65% of total income. (Further results are given in MART/AZR Research Report 5).

b). Informal Range-livestock Survey (1987).

An informal survey highlighting range-livestock constraints and priority problems was conducted at the Zarchi and Tomagh range sites in collaboration with the agronomy and range-livestock groups.

The principal production constraints were identified by the herders of these two areas. These were:

Low and erratic inter and intra year rainfall,
Low soil fertility,
Low rangeland productivity,
Feed shortages in the winter months,
Availability of additional land of good quality for the growth of forage crops,
No overall management of common grazing land which has led to overgrazing and deforestation,
Vegetation slow to grow in spring (Tomagh area),
Problems with livestock diseases and little effective use of veterinary services.

Additional information is presented in MART/AZR Research Report 3.

c). Household Agricultural Production Systems Formal Survey.

The results of this survey are exhaustively covered in a number of MART/AZR documents in particular, MART/AZR 54 " Rainfed agriculture in

highland Baluchistan", MART/AZR 50 "Animal raising in highland Baluchistan", MART/AZR 7 "Household agricultural systems survey results", MART/AZR 10 "Women's household agricultural production systems survey results" and MART/AZR 47 "Women's participation in the high elevation farming systems of Baluchistan, Pakistan. This latter document is presented in greater detail in this report as an example of the type of material reported by the MART/AZR project.

A survey of 200 household heads, 40 in each of five upland Baluchistan locations, and 72 wives of household heads in three locations were completed in months of May to July, 1987.

The importance of women's activities is not always proportionate with their access to and control over resources and income. Access to and control over resources within farming systems largely stem from the economic and socio-cultural environment which has developed over centuries. The main objectives of this study were to (1) identify the specific areas of the farming systems of Balochistan that rural women participate in, and (2) define the relevant socio-cultural factors which limit women's participation in the farming systems and the consequences this has for women's control of household resources and income.

Female labor as a percentage of the agricultural labor force for Asian countries has been estimated to range between 24 to 50% and as the results of this study show, women's role in agricultural production is not only critical to the household but all women are involved in these activities.

The rural female literacy rate in Balochistan is less than 2% and is one-quarter of the national average. The average age of the women respondents was 45. In the Ferozabad and Dasht Valleys, 95 and 83%, respectively, of the respondents were wives of the heads of the household. In Tomagh, 27% of the respondents were mothers of the male household heads and may indicate an ethnic group difference in the authority structure. None of the women interviewed were household heads in their own right. This does not necessarily imply that there

Valleys, 95 and 83%, respectively, of the respondents were wives of the heads of the household. In Tomagh, 27% of the respondents were mothers of the male household heads and may indicate an ethnic group difference in the authority structure. None of the women interviewed were household heads in their own right. This does not necessarily imply that there are no women heads of households in Balochistan, but rather that the survey methodology focused on spouses of heads of households to obtain complementary information. Seventy-five percent of respondents in Ferozabad and Dasht and 58% in Tomagh indicated that other adult women lived in the same household. Respondents indicated to the interviewers that the majority of these women were the husband's mother and sisters in Tomagh, but in Ferozabad and Dasht, over half were distant relatives.

Women participate in all tasks with the exception of migrant wage labor, commerce and transport, and building and maintenance which require a displacement from the home grounds. Gardening; food preparation; the cleaning, carding, spinning and weaving of wool; child care (human capital production); midwifery; helping the sick; and making clothes are exclusively female tasks in which female children and young boys may also participate. For the most part, those tasks associated with agricultural and livestock production, for example, planting, harvesting, threshing, crop storage, most livestock tasks, hauling water, gathering firewood and milling grains, are shared by both males and females to different degrees depending on the community. Respondents indicated that hired help was used mainly for herding livestock. Results from the survey of the male household heads, however, indicated that a small number of farmers hired help for planting, harvesting, threshing and hauling water.

Women also engage in some income generating activities either in their homes or in the community, such as weaving and embroidery, or services (caring for sick, midwifery) which give them a small revenue.

Few of the respondents owned land (6 out of 72 respondents) and this was received as an inheritance according to Islamic Law and entrusted to others to

work. Land is never given as part of a dowry. The amount of land owned was between 0.4 and 1.5 hectares. Respondents in Ferozabad owned Khushkaba land and those in Tomagh owned irrigated land. None of the respondents can buy land in their own right even if they had money to dispose off. Indeed, the decision to buy, sell, or rent land by any member of the household, male or female, does not always reside with the individual or family. The permission of the tribal or village leader is required in most cases. Tomagh was the exception where 38% of the respondents said that the individual or family can decide, land transactions. Women have access to land for grazing livestock and for gardens but not control over the land.

The same respondents who owned land also owned livestock, but only a few sheep, goats and cows. This ownership is somewhat theoretical, since the animals are given to women by their father or brothers who retain control over them. In these cases women may be given part of the wool or milk derived from the livestock they "own." Chickens are the property of the household and the women do not sell the eggs. The only case of ownership of chickens was found in Tomagh.

The contribution of women in the rainfed farming systems of upland Balochistan extends into all aspects of household and agricultural production and this contribution is critical to the maintenance and survival of the household. Despite their critical role, however, women are circumscribed by cultural and religious factors and occupy a subservient role to males in the household which deprives them of control of material goods and productive processes. Moreover, the access to resources and related opportunities is limited in this instance, not only by the religious and cultural norms, but also by the marginal situation of the entire system which also limits the range of actions of men and deprives all but a few people of access to land, credit, educational facilities, and basic services.

d). Upland Wheat-Barley Survey (1988).

A formal survey of 86 wheat and barley farmers was conducted in June, 1988. The survey provides information on barley production, marketing and farmers decision making vis-a-vis wheat production. The work was undertaken in collaboration with the agronomy and germplasm research groups. The data has been analyzed and reported in detail in MART/AZR Research Reports 24 and 26. In summary, the conclusions of this work were:

The growth rate in hectarage of rainfed barley is much higher than that of wheat in upland Baluchistan but overall barley production is quite small relative to wheat production. Thus, the increase in rainfed wheat production per year is larger by a factor of 3 to 4 over the increase in barley production per year. The barley growth rates do, however, indicate that the industry is active.

Farmers indicated that the same fields were sown to the same crops with regularity. When a crop sequence was used, it was most often monocropping with wheat or barley. Farmers perceptions were that rainfed barley yields on average were at least comparable to, and most often higher, than rainfed wheat yields. Most wheat grain is consumed for food or sold. Most barley grain is sold. Small amounts of wheat and barley grain are fed to the farmers own livestock. A high proportion of the wheat and barley straw is sold with animals being fed most of the remainder. There is an indication that wheat and barley grain prices in poor agricultural years do not exhibit the differences that are seen in good agricultural years.

Differences in land quality on which wheat and barley is sown, diseases, birds, and insect production problems seem not to be greater for barley than wheat and therefore not reasons for greater wheat hectarage or lower barley yields. There may be other reasons, such as poorer barley seed, the planting of the more important wheat crop before barley giving wheat an advantage of better moisture conditions, or better wheat management practices that were not disclosed by the present survey. The variability analysis suggested that rainfed barley

yield was less variable (risky) than rainfed wheat production. Thus farmer's reasons for growing less barley than wheat may have to do more with growing wheat for food security and with the present small uncertain barley market than with production problems.

Most farmers indicated that they would grow more barley if the barley yield or barley price increased by 50% to 100%. This is their risk premium to forgo growing wheat for food security and/or for coping with the risk involved with marketing barley. Many farmers indicted that land resources were scarce and that they would only replace wheat hectarage with barley given the 50% to 100% risk premium.

The future for increased barley production within the farming system of upland Baluchistan seems to hinge on the two aspects of growing wheat for food security and the market for barley. Baluchistan society is in a state of transition as it reacts to social and economic forces both from within and from outside its borders. The question of growing wheat for food security by dryland farmers may give way as increased migration from the rural areas takes place and farmers become more commercial in outlook. Greater feed demands that are projected from small ruminant producers may also act as a stimulus for a changeover to increased forage production such as barley.

A main impediment to the increase in barley production seems to be the small and uncertain market for barley. Even at current prices and yields, a secure market for barley would probably solicit an expansion in production. However, marginal increases (up to 25%) in either barley yield or barley price given the current barley market would not encourage much increased barley production. The barley market could be made more secure by better government regulation and improved infrastructure. What the barley industry needs, however, is a larger market. Baluchistan probably does not have a comparative advantage in exporting barley to other provinces or abroad. Its only major hope for increase lies in an expanded commercial livestock industry where it can be used for both grain and fodder.

e). Secondary Data Collection.

Work has been done to compile secondary data pertaining to upland Baluchistan into two volumes for convenient reference. The first Research Report MART/AZR 20 details crop statistics, agricultural development statistics etc. the second Research Report MART/AZR 43 details livestock production, statistics and gives details of local breed characteristics of large and small ruminants.

f). Harvesting and Threshing Labour Data Collection.

Labour times for the harvesting and threshing of wheat, barley, lentils and Vicia sp. have been collected from time and motion studies. This technical data is required for both economic budget analysis and whole farm modeling. The research was done in collaboration with the agronomy group and has been used in the partial budgets reported in MART/AZR Research Reports 51 and 52.

g). Sheep and Goat Production in the Farming Systems of Upland Baluchistan.

An analysis of the production of sheep and goats in Baluchistan was conducted based on the results of the formal and informal survey (MART/AZR Research Reports 3 and 7) and from secondary data sources (MART/AZR Research Report 43). Full results are presented in MART/AZR Research Reports 28 "Descriptive and diagnostic studies of sheep and goat production in the farming systems of upland Balochistan" and MART/AZR Research Report 50 "Animal raising in Highland Balochistan: A socio-economic perspective".

The specific purpose of the descriptive and diagnostic livestock work in the AZRI research program is to: 1) describe and better understand the production and marketing constraints and priority problems of sheep and goat farmers and herders, and, 2) develop hypotheses about major research and extension opportunities that may exist for the upland

Baluchistan range-livestock industry based on the descriptive and diagnostic information.

The sheep and goat industry of Baluchistan is set within a harsh climatic environment and characterized by small flocks obtaining most of their feed from relatively unproductive rangeland. The industry is very important to the economy of Baluchistan even though most flocks are secondary enterprises and used as a store of wealth rather than as a commercial business.

Major constraints to improved sheep and goat productivity are: (1) poor nutrition because of the low productivity of the rangelands and the non-availability of economic supplemental feeds, (2) disease and parasite problems because of limited veterinary coverage, (3) poor flock management, (4) poor credit, marketing and transportation infrastructure, (5) no range management or control on the common tribal rangelands, (6) poor genetic potential of animals, and (7) no overall strategy that coordinates and guides research and extension for the industry.

Suggestions for research and extension interventions include: (1) the introduction of perennial legumes, cool season grasses, and shrub reserves to rehabilitate the rangeland, (2) grazing control studies on the number and kinds of animals and appropriate seasons of use, (3) dryland fodder production combining new forage species, fertilizer, and water harvesting, (4) increasing the nutritive value of crop residues and the use of non-conventional feeds, (5) providing farmers with the knowledge to vaccinate and dip their own animals, (6) flock management, credit and infrastructural improvement and (7) increasing the genetic potential of the animals.

Socio-economic comparative advantage and marketing research is also required to determine how the industry might evolve in the future to ensure appropriate programs of research and extension.

An important step in increasing the productivity of the Baluchistan sheep and goat industry over the longer run is the development of an overall strategy to guide the industry over the next decade or two.

This strategy would include the role and direction that research and extension would take. The development of such a strategy requires socio-economic research that may take several years to complete.

Meanwhile, the research and extension community can contribute to the development of the industry's strategy. Given the major constraints to increased productivity and hypotheses about the major interventions to alleviate the constraints, the next step leading to the design of research and extension programs is to weight all the hypothesized interventions with respect to their social and economic consequences. Ex-ante economic budgeting and whole farm modeling of proposed interventions can be carried out to screen the interventions indicating their profitability and possible adoption by farmers. A further step is then to develop research and extension programs that target their efforts to developing and disseminating interventions sequentially for the short (within 5 years), intermediate (5 to 10 years) and the longer run.

Given the present research and extension knowledge and technology availability, in general, the impact on the industry in the short run could most likely come from increased health coverage and improved management practices. Intermediate interventions would involve supplementary feed improvement from dryland fodder production, non-conventional feeds and forage shrub reserves. Long term impacts would come from improved genetics and range rehabilitation and control. Credit, marketing and infrastructure improvements can have an impact in all three periods given committed government support.

2. Technology Evaluation.

a). Partial Economic Budgets and risk analysis.

Partial economic budgets and rates of return of the 1985-86 and 1986-87 agronomy and farmer-managed trials were completed and reported in the MART/AZR 1987-88 Annual Report. Further analysis on the farmer-managed trial is reported in MART/AZR

Research Report 12 and for agronomy trials in MART/AZR Research Reports 51 and 52.

b). Cooperative Farmers Survey.

At the end of the 1987 cropping season, 20 farmers from the Kovak farmer-managed trials were given a questionnaire to ascertain their awareness of the trial objectives, their assessment of the interventions, and problems that they experienced with the interventions. The results appear in MART/AZR Research Report 12. The research was done in collaboration with the agronomy and extension groups.

c). Ex-ante Estimation of the Rate of Return to Agricultural Research at AZRI.

PARC Islamabad expressed an interest in having an analysis of possible future rate of returns to research expenditure at AZRI. Partial budgets for traditional farming practices and for crop and livestock interventions in Good, Normal and Poor agricultural rainfall years based on available trial data and best estimates were constructed. A rate of return was calculated based on the economic surplus provided by the interventions over that of the traditional practices against an estimate of the cost of AZRI undertaking the research. The research was undertaken in collaboration with all MART/AZR research groups and is reported in MART/AZR Research Report 35.

Ex-ante economic analysis is used to screen interventions to identify those that have a high likelihood of being profitable for the farmer to adopt. This information is then provided to extension services and is also used as feedback for the modification of the research program. An Ex ante economic evaluation of eight health (vaccination and dipping), flock management, high energy feeding, and breeding intervention combinations for the improvement of sheep production in Baluchistan were analyzed using a sheep flock budgeting model. The objective was to provide information for research and extension program design prior to the undertaking of a full experimentation program.

The budgeting model included both technical performance and economic parameters using synthesized data from limited available experiments supplemented by informal and formal farmer and key informant survey information. Results indicated that health and flock management interventions were highly profitable, suggesting that vaccine and dipping solution availability and farmer knowledge were the key constraints to their further usage. Interventions involving feeding failed to prove to be economical, suggesting that research programs should turn to lower-cost feeding regimes.

FUTURE RESEARCH DIRECTIONS

To date, the FS/Econ work has been weighted toward description and diagnosis of the upland Balochistan farming systems. The plan has always been to shift the emphasis more towards technology evaluation once the AZRI research program becomes more mature. However, there must be a continual commitment to descriptive and diagnostics work at AZRI because: 1) the farming systems of Baluchistan are dynamic and will see rapid changes over the next two decades - the farming systems will be influenced by interventions from AZRI and other research institutions and by outside economic and social forces and this information is crucial to the design of an on-going research program, and 2) AZRI will be involved in research at new locations that will require base-line data and diagnostics.

The FS/Econ research program as it stands gives AZRI a foundation upon which to continue and further build farming systems and socio-economic research. As AZRI matures and the FS/Econ staff's education and experience increases, whole farm modeling, risk analysis and macro socio-economic issues such as marketing, agricultural and consumer subsidies, exchange rate policy, product and input pricing policies, transportation, tariffs and energy pricing, all of which can have an effect on technology

adoption, can be included in the research program (MART/AZR Research Report 15).

Monitoring and assessing the impact of research will become more important as the AZRI research program matures and interventions are taken up by farmers. The Ex-ante rate of return study is an attempt to assess the possible pay-offs at the Micro level (farmer) and at the Macro level (Government) as well as providing guidance for a research strategy.

TRAINING WORKSHOPS.

Three training workshops were jointly sponsored by the agronomy and farming systems groups at AZRI which were attended by all AZRI scientific staff and representatives of provincial government research organizations. These workshops were:

1. Introductory Computer Workshop, Dec.1986
2. Biometrics II Workshop, Dec. 1986
3. MSTAT Workshop, January, 1987

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RANGE-LIVESTOCK RESEARCH

INTRODUCTION

Project Background

The assignment of a Range-Livestock Adviser to the Arid Zone Research Institute (AZRI) was proposed in the Management of Agricultural Research and Technology (MART) Project PC-1 in August, 1984. Responsibilities of the "range management/livestock scientist" (later called the Range-Livestock Adviser) were to include advice and supervision in the following research topics: "Design and testing of a viable, integrated range/forage/grazing management system that satisfies the demands of sheep and goat owners and conserves the natural resource base"; testing of "crops suitable for grazing, fodder, and hay and straw production"; surveys to identify "the principal causes of mortality and morbidity among livestock herds and the extent to which mortality and fertility rates can be influenced by improved animal health and nutrition practices"; and feed supplements which could be introduced "to augment currently available animal feed in the dry areas.

Special emphasis was to be placed on "rangeland and livestock research, due to the importance of livestock in the agricultural systems of Balochistan." Range management and livestock management research activities identified in the MART PC-1 included: (a) trials of selected perennial grasses suitable for rangeland production and stabilization and adapted to existing animal management practices in Balochistan, (b) range ecology studies involving exclosures, grazing responses, and plant collections, and (c) range livestock nutrition studies on the relationships between range forage, supplemental feeding options, and animal production.

The MART PC-1 also listed as range management and livestock research activities the "development of an outreach/extension/demonstration program for technology transfer in cooperation with extension personnel; and, study of the factors affecting and

governing the management and marketing of livestock produced under range conditions." However, primary responsibility for these concerns would more appropriately rest with the Extension and the Agricultural Economics sections of the project. Likewise, testing of fodder crops for hay and straw production, as mentioned above, lies within the purview of the Agronomy section, with inputs from the Germplasm section.

The Colorado State University subcontract with ICARDA contained two basic premises, i.e.,"(a) the scope of the livestock/rangeland research at AZRI should be dramatically reduced to very few well-defined project areas and (b) the research should have an interdisciplinary nature which is the essence of the farming systems approach." Much detail related to these two premises was also included in the scope of work statement under which the Range-Livestock Adviser was to function. After careful review of the actual situation at AZRI and in Balochistan, with regard to the status and needs of the range-livestock research program, the terms of reference of the Range-Livestock Adviser were adjusted to fit the realities and requirements of the project. This was done with respect to the stated premises as well as to the broad objective of developing a range-livestock research program able to serve the needs of sheep and goat producers, while supporting conservation of the natural resource base on which a sustainable agropastoral system depends.

Rangelands and National Objectives

The Report of the National Commission on Agriculture (NCA) in 1988 emphasized the importance of range management in the economy of Pakistan, stating that almost 40 percent of Pakistan's 40 million sheep and goats depend on range forage as their primary feed source. The NCA estimated that more than 50 percent of the total area of Pakistan is classified as rangeland, and of that area more than 50 percent is in Balochistan. Another 30 percent of the nation's rangeland is located in Sind and Punjab provinces, where AZRI also has a role in range and livestock research. It should be noted that these

estimates of land areas considered as "rangeland" are probably conservative, because much of what is classified as "forest" and "wasteland" in the arid and semiarid zones of Pakistan is used primarily for grazing.

To meet its target of almost doubling production of meat from sheep and goats by the end of this century, the NCA urged limits on herd growth and emphasis on increasing meat output per animal. The report suggested that achieving this objective will depend on the availability of the quality and quantity of feed needed to realize the marginal return advantages possible with improved nutrition of the present livestock inventory. According to their analysis, economic returns can be much greater from increasing rations to the existing animal stock as compared to using additional feed to give the current rations to a larger herd. Assuming this generalization to be correct, and substituting "forage" for "rations", a more specific case can be made for the introduction of higher-producing, more nutritious range forage species, including the establishment of fodder shrub reserves. Improved animal genetic stock and health cover are also key factors in efficient use of feed resources.

Specific range research and development activities recommended by the NCA included: testing of new range grasses, shrubs, and fodder trees in different ecological zones; study of grazing systems; use of water harvesting techniques to increase forage production; and establishment of large-scale seed multiplication facilities to provide high quality range seeds of adapted species.

BUILDING THE RANGE-LIVESTOCK RESEARCH PROGRAM AT AZRI

Critical Issues

Creation of a successful range-livestock research program at AZRI started with the mandate of the USAID-sponsored MART Project (MART-AZR Component, hereafter referred to as the "project") which emphasized institution-building and training. The objective of the project was to "generate and disseminate quality and relevant technologies applicable to the non-irrigated areas of the country." In terms of range-livestock production this covered a variety of potential research targets and strategies, but the most important concerned forage deficiencies at critical periods in the production cycles of livestock, and the two-pronged issue of grazing management and animal husbandry.

Institution-building in this context required an action plan which (a) focused on these key issues, (b) provided facilities for both range and livestock studies, (c) recognized the capabilities and needs of the AZRI staff, and (d) coordinated with other research efforts. Training was needed at every level and in almost every technical area of the institution, including the range-livestock section.

IMPLEMENTATION

Staffing

Development and proper utilization of staff are at the heart of any institution-building effort. This truth has affected the pulse and pace of range-livestock research at AZRI from long before the project began right up to the present. Building a truly functional range-livestock research program at AZRI placed demands on the existing staff which went well beyond their backgrounds of training and experience. The reach of the plan exceeded the grasp of the staff; but some stretching of minds and methods was desirable, by design.

At the outset of the project the resident, on-duty range-livestock staff at AZRI consisted of the following professionals: Three S.O.'s (animal

science), two S.O.'s (veterinary medicine), and one A.S.O. (forestry). As this report is being prepared the on-duty staff make-up is: One S.S.O. (animal nutrition), one S.S.O. (forestry-range management), one S.O. (animal nutrition), one S.O. (range management), and one A.S.O. (botany).

During the intervening four years the range-livestock staff has had a number of changes, including: three resignations from the original six members (one D.V.M., one S.O., animal science and one A.S.O., forestry); two recruitments of botanists who later resigned; and the loss by transfer of three D.V.M.'s. One of the original two D.V.M.'s departed for in-country M.Sc. training in 1988 and another D.V.M. recruited in 1987 left for long-term degree studies in the U.S. after one year at AZRI. At present there is no clinical or research D.V.M. at AZRI.

The relationship of animal health to productivity, the need for animal health studies to deal with specific problems, and the needs of research livestock for routine and emergency veterinary care all support the long-standing request of the Range-Livestock Adviser and AZRI directors for the assignment of at least one qualified D.V.M. at AZRI.

One of the original S.O.'s (animal science) has been away on a long-term degree program for most of the time since 1986. The present S.O., animal nutrition, is expected to depart for long-term training in January, 1990, at which time the on-duty range-livestock professional staff would total four. The one remaining animal science S.S.O. expected to be on-duty in January will be solely responsible for the entire AZRI livestock research program. Range management research will be handled by the other three scientists in the section.

Physical Facilities

When the project started in 1985 the physical facilities available to AZRI for conducting range management and livestock research consisted of some 10 ha of protected native range at Quetta and the 18,000-ha Maslakh Range area approximately 25 km west of Quetta.

Maslakh was carefully examined for its potential as a key research site for range-livestock and coordinated agro-pastoral studies. In order to include the inputs of key individuals with current or past involvement in research and development activities at Maslakh, an informal workshop was held in Islamabad the 9th and 10th of March, 1986 to explore the merits of conducting AZRI range-livestock research at that location. The workshop participants recommended that AZRI proceed with its proposed program at Maslakh.

Action plans were nearly in place by early 1986 when the security situation in the Maslakh area dictated abandonment of further work there until such time as the conditions for frequent travel to this locality were considered safe by competent authorities. The loss of Maslakh as a viable AZRI and project research site was a disruptive element in the process of building a solid base for the range-livestock research program. However, despite the mostly favorable publicity that Maslakh has received through the years for the pioneering range work done there starting 30 years ago, opinions are not unanimous on the merits of using Maslakh for station-oriented range research and development activities. At some point in the future, when AZRI's range-livestock program has matured sufficiently and its scope of work has broadened enough to include more livestock owner participation, access to Maslakh as a nearby research site could make it a more attractive option than it has been to date.

AZRI was faced with the challenge of finding suitable alternative sites for study of range and animal responses to grazing and livestock management practices. The decision was made, in agreement with the contract, to limit field operations to two locations, each representing a different ecological

zone. Sufficient rangeland was required to accommodate study of different grazing systems and the performance of research animals under natural range conditions. Reliable water supplies were needed to support establishment of permanent research stations. Access to the grazing lands by AZRI had to be possible with a minimum of conflict with local graziers.

After extensive searches and many consultations with provincial officers and potential cooperators two sites were selected: "Tomagh" in Loralai District and "Zarchi" in Kalat District. Each site was chosen to be representative of different major range types in upland Balochistan. Tomagh is located in a transition zone between a plains grassland type and a mixed shrub foothills type, affording opportunities for research in both kinds of vegetation. Zarchi is located in a desert shrub type dominated by Artemisia and Haloxylon, similar to the vegetation at Maslakh.

Tomagh Range Livestock Research Station is situated on the 4,000-ha Tomagh State Forest 15 km west of Sanjawi in the elevational zone of 1800 m to 2000 m. The estimated mean annual precipitation at Tomagh headquarters is 300 mm, which is distributed approximately 60 percent and 40 percent, respectively, between the winter and summer rainfall periods.

Zarchi Range-Livestock Research Station is located on 4,000 ha of privately-controlled land 20 km west of Kalat at an elevation of 1800 m. The estimated mean annual precipitation at Zarchi is 200 mm, 90 percent of which occurs in the winter-early spring period.

Development of these range-livestock research stations --the first for AZRI, and perhaps in Balochistan--began in May, 1986. Research operations were underway at both stations that fall. During the winter and spring of 1985-86 the Animal Nutrition Unit and pasture blocks at Zarchi were made operational. Water systems were in operation, sheep and goat flocks were under study, and the first range exclosures were established.

Construction of these facilities involved a great deal of planning, supervision, and

determination by the Range-Livestock Adviser and the AZRI staff. None of the AZRI officers had ever been involved in the various technical, mechanical, and logistical aspects of building the station facilities needed for this program. The fact that several of the AZRI scientific officers emerged as good physical development managers, acquired valuable knowledge about these matters, and gained essential confidence in themselves was one of the most rewarding packages of achievements in the process of institution-building within the Range-Livestock Section.

It is unfortunate that two of the most effective officers during the development phase are no longer at AZRI, where their talents are now sorely missed. This does not reflect on the merits of the process launched or the progress made but rather on the regrettably high turnover rate of AZRI scientific staff. In October, 1989 the Range-Livestock Adviser was the senior-most, in terms of service at AZRI, of on-duty "staff" in the Range-Livestock Section. All four AZRI officers then on-duty had arrived at AZRI, or returned to AZRI, since 1986. One officer had joined the staff as recently as July, 1989.

Research Activities and Results

The research program in the Range-Livestock Section has been structured within the two basic headings of range management and livestock management. This division is used to facilitate supervision of work and to reflect educational and job specialization on the staff. The emphasis on "management" as an orientation for the research program is intended to focus the framing of scientific questions that will lead to biologically and economically significant answers.

Experience in many fields teaches that improving management decisions and removing management defects can be the most promising areas for increasing the productivity of a system. Production of range livestock is no exception. AZRI scientific officers in this subject area have now been exposed to the concept and method of designing studies which ask the right kinds of questions about real problems. Most of the research questions posed by the Range-Livestock

Section have a "better management" objective directly or indirectly related to practical needs of producers.

Range management

This work at AZRI includes grazing studies, range rehabilitation trials, and range plant collections. Grazing studies established at Zarchi are measuring vegetation and animal responses to deferred-rotation vs. continuous grazing and comparisons between sheep and goat grazing on the shrub range. At Tomagh a season-of-use grazing experiment was established to compare vegetation responses to different short-season deferments. Exclosures are providing some useful information on responses of range vegetation to protection from grazing.

Results from these grazing studies have been sparse and slow, as might be expected in this climatic zone. However, one result of this effort is the general observation that even under complete protection from grazing for three years the range vegetation at both of the field stations shows less recovery than might be considered sufficient to support economically useful grazing management recommendations.

The lack of land control, a common problem in Balochistan on both public and private ranges, can preclude meaningful results from grazing studies in which the effects of trespass, non-study animals cannot be dealt with in the analysis. To mitigate this problem an innovative technique has been introduced at Tomagh and Zarchi which uses a "passive" grazing treatment system vs. the conventional "active" approach in which the researcher controls both the range and the livestock.

Under the "passive" technique developed on this project controlled (fenced) treatment plots are located in areas grazed by local flocks which are not under the researchers' direct control. The researchers merely control the configuration of the exclosure blocks, by opening or closing gates or fence units, to observe vegetation responses from

ambient grazing pressure. Hence, the approach is "passive" so far as the researchers' direct control of the animals is concerned. The controlled treatment plots are, in effect, "passive" relative to the active grazing practices of the local herders. This means that researchers need not herd animals nor control large areas of rangeland in order to measure the effects of grazing at given seasons on designated treatment plots.

The design and operation of "passive" vs. "active" grazing studies is not without demands on plot maintenance and control. To be fully effective, the technique requires the researcher (a) to have good knowledge of the seasonal grazing practices of local herders and (b) to locate the "passive" treatment blocks so as to intercept sufficient livestock during the seasons of interest to obtain the vegetation response data desired. Further refinement of this research technique could eventually help to solve the general and persistent problem of land control as it affects grazing studies.

The observations of vegetation response to grazing control are not only of basic ecological interest, but also provide some initial support for efforts to introduce new range plants into these ecosystems. In the case of the desert shrub type at Zarchi, grazing exclusion has produced only modest improvement in the vigor of the existing plants and essentially no increase in numbers or kinds of plants present in the exclosures. The shrubland range at Zarchi is almost devoid of grasses, although this might not have always been the case. Historical information on the vegetation in this region is almost as scarce as the grass, but it is reasonable to postulate that the Artemisia-Haloxylon type in this area at some time in the past did support a perennial grass component, or, in other words, what is present today is a substantially degraded shrub-steppe, and ecologically a good candidate for (re)introduction of adapted perennial grasses.

The grassland type at Tomagh has responded more vigorously to protection, but with little or no reproduction of desirable grass species. The Cymbopogon-Chrysopogon community in this area is

Local livestock owners who have seen this trial have requested, and received, fourwing saltbush seedlings for establishment of similar forage reserve blocks on their own land. Fourwing saltbush has been planted in a large block at Zarchi where occasional flooding should support vigorous growth of the shrubs without further irrigation.

A study was started in 1987 to evaluate establishment of fourwing saltbush within stands of perennial grasses. The study site had a total plant cover of 20 percent, of which total Cymbopogon jawarancusa contributed almost 75 percent and Chrysopogon aucheri slightly less than 25 percent. Three-month old seedlings of fourwing saltbush were transplanted into openings in the grassland in July and given four liters of water at time of planting and a second irrigation of four liters two months later. During that period the site received only 27 mm of rainfall, and during the next 10 months only an additional 147 mm of precipitation. Fifty percent of the transplants survived the first year, despite heavy grazing by rabbits, and about 90 percent of the survivors were still growing after two years. Based on this initial, limited test of a somewhat unconventional approach to range plant introductions, additional trials have been proposed, with emphasis on land treatment methods that increase soil water accumulation near the transplants.

Water harvesting techniques of various kinds should prove to be highly effective in growing vigorous stands of fourwing saltbush. Under favorable moisture conditions a stand of fourwing saltbush can be ready for heavy grazing use in less than one year. When established on dryland sites, with only initial irrigation, fourwing saltbush stands might need three years before they are at the proper size for such use. Once established, a stand of fourwing saltbush should be able to survive indefinitely under the climatic conditions of upland Balochistan even with moderately heavy utilization and with minimal water from whatever sources are available.

Livestock management

This research at AZRI has emphasized the nutritional aspects of small ruminant production in Balochistan. In addition, the incidence of parasites in sheep and goats has been studied. The latter topic is often dealt with as a distinct problem within the area of veterinary medicine; however, control of parasitism is a key factor in achieving optimum use of feed, the latter being mainly the concern of flock owners. Therefore, the designations used for the two arms of the livestock management program at AZRI, i.e., "animal nutrition" and "animal health", are somewhat artificial. The nutritional status of an animal is generally the most important factor in its overall health, and reciprocally, the "health" status of an animal, e.g., its level of stress from disease or parasites, can have a major effect on the uptake and utilization of its feed.

Studies were conducted by AZRI to measure the effect of nutritional interventions on the fertility and productivity of sheep and to compare the forage value of fourwing salt-bush with other feed sources. The dominant livestock management problem in dry regions is inadequate quantity and quality of feed during critical periods in the animals' production cycles. The most serious feed deficits for small ruminants in the drier areas of Balochistan usually occur in early fall and again in mid-winter, which coincide with the typical breeding and late gestation periods, respectively. AZRI livestock management research has tried to focus on this problem in two ways. First, experiments were set up to observe animal responses to supplementation of range grazing during critical periods of feed deficit. Second, studies were conducted to evaluate one of the more promising options as a forage reserve or supplemental feed source: fourwing saltbush.

Eighty-one Harnai ewes grazing native range were used in one experiment at Tomagh designed to examine the effect of flushing and late-gestation supplementary feeding on ewe fertility and productivity. The animals were divided into three groups of 27 animals each. The three groups were assigned three flushing treatments at random: barley

anthelmintics, with results that could be useful to animal health officers and livestock owners.

Recommendations for Future Research

Staffing

Any suggestions regarding numbers and categories of staff positions which AZRI needs to maintain must be considered in the context of PARC's goals and constraints in arid lands research. The goals have been broadly stated numerous times and more specifically defined by many interested parties over the years. MART-AZR project advisers have made serious and, it is hoped, constructive contributions to setting realistic goals for AZRI. It is in the area of "constraints" that outside advisers and sponsors, as well as PARC administrators, share the greatest difficulties in matching means with mission. Present funding for AZRI clearly will not support all of the range-livestock research activities which have been proposed in the development of this project.

Staffing costs, both direct and indirect, represent the major area of expense for AZRI. Selectivity and restraint in staff development must be applied before any substantial budget cuts can be effective. However, if it is accepted that the range management and range livestock sectors of AZRI are to play an even greater research role in the future, there appears to be little slack in this area for reduction of staff. The question might be how to maintain about the current size of the Range-Livestock staff, with some adjustments in specialization, while cutting back elsewhere. The following professional staffing for the Range-Livestock Section is recommended:

No.	Grades	Degree Levels	Specialities
1	S.S.O.	Ph.D.	Range Management
1	S.S.O.	Ph.D.	Range Animal nutrition
1	S.O.	M.Sc.	Range Rehabilitation
1	S.O.	M.Sc.	Range Animal Nutrition
1	S.O.	D.V.M.	Small Ruminants
1	A.S.O.	B.Sc./ M.Sc.	Silviculture/Plant Materials
1	A.S.O.	B.Sc./ M.Sc.	Plant Taxonomy/Ecology

AZRI should recruit, train, and reward the best available technical staff to assist the scientific officers. This project has seen how experienced and dedicated field assistants can make the difference between success and failure. Development of this element of the AZRI staff should not be overlooked in future budgets and work plans. AZRI could improve its research management by retaining fewer, but better, support staff, in proper balance with a realistic scope of work.

Physical Facilities

Future AZRI budgets will probably require adjustments in the field research program to effect cuts in travel-related costs and some reductions in field station personnel expenses. A shift of emphasis in the work plans toward conducting more studies close to AZRI headquarters might require new or expanded physical facilities at or near Quetta in order to take advantage of savings in travel costs. Additions to the facilities at Quetta should include the following: shrub and tree nurseries, a greenhouse, barns and feed processing equipment, fences, and guard houses. Requests for specific items of animal nutrition laboratory equipment, which have been pending for many months, should be met soon.

Improvements should be made at both Tomagh and Zarchi to facilitate easier handling of livestock, which will become more critical with reduced staffing levels. Barns for feed storage should be built and

after planting, apparently in response to more favorable soil moisture conditions operating alone or combined with other factors. Desert ricegrass would be well adapted to the lighter-textured soils and the drier zones of upland Balochistan. Its potential as a reseeding species should be further tested, and, if justified by performance in block seedlings, desert ricegrass should be considered as a good candidate for a commercial seed production project. Present cost of desert ricegrass seed would seem to preclude its widespread use in Pakistan as a range reseeding species. However, if its seed could be locally produced desert ricegrass could fill a critical need for a large-seeded, drought-tolerant and palatable grass for rehabilitation of certain degraded shrub-steppe rangelands.

Plant selection and improvement work should be done with steppe wildrye (Elymus junceus) to develop a locally-adapted cultivar that will germinate and establish more vigorously than presently available germplasm. This species could be recommended for reseeding certain range types if its performance in the first three months after planting can be improved. Efforts should concentrate on selecting large-seeded material that will produce vigorous seedlings and good germination percentages under conditions of cold and moisture stress. Plants of steppe wildrye that survive the first six months to one year after planting appear to have a greater capacity to make growth and set seed than do most of the better-adapted wheatgrasses. Survival and reproductive characteristics of this species make it a worthy candidate for in-depth range germplasm studies by AZRI.

It will be important to quantify small ruminant responses to the feeding (or browsing access) of fourwing saltbush. Again, the focus should remain on the feed deficit problem in critical phases of the production cycle. Questions to answer include: When does the addition of a forage shrub "supplement" (such as provided by fourwing saltbush) give the greatest gain in animal performance? Can short periods, e.g., up to one hour's duration, of fourwing saltbush browsing by sheep and goats on a once-per-day or twice-per-day schedule increase weights or

productivity? Should fourwing saltbush forage reserves be used to provide a major portion of the animals' diets only during certain critical seasons when other vegetation cannot meet basic nutritional needs, e.g., during flushing, breeding, or late-gestation? What effects result from combinations of fourwing saltbush browsing with energy and/or protein supplements? What effects do access, or lack of access, to drinking water have on small ruminants receiving all or most of their diets from fourwing saltbush? What effects do diets rich in fourwing saltbush have on lactating ewes and their nursing lambs?

Animal nutrition studies should be expanded to provide basic data on the nutritive values of range plants during different seasons of the year. Weights and other parameters of local flocks could be monitored and correlated with range forage quantities and qualities to estimate what types and levels of nutritional management interventions would be feasible under actual rangeland production conditions.

Further studies should be designed (and carried out if competent staff are available) to evaluate the biologic and economic effects of parasitism and disease in sheep and goats. Much has been said about this subject, and a good start has been made to lay an information and experience base at AZRI, but questions remain to be answered. The issue now lies with PARC in terms of its commitment to animal health research at AZRI.

Livestock management practices used by flock owners in Balochistan offer considerable room for improvement, according to a number of qualified professional observers. AZRI should make full use of the survey data collected by the Economics and Extension sections, and other relevant information, to develop a livestock management research program which integrates a number of the areas already discussed. Questions raised in this effort should focus on how to apply better nutritional management and basic health care for small ruminants in ways that are biologically and economically more efficient and profitable for the farmers. Implementation of this research will require not only more inputs from

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AGRONOMY

INTRODUCTION

The Agronomy Advisor arrived at post in September 1985, with the brief of training AZRI scientists by involving them in agronomic research appropriate to the rain-fed crops of upland Balochistan, in a farming systems oriented program. In the period 1980-85, though skeletal in nature and largely unpublished, some agronomic research had been carried out at AZRI. This experience helped to formulate the areas initially suggested for research in the MART PC1. However, there was insufficient hard agronomic data to avoid the necessity of having a broadly based research program of problem identification in the first instance. Therefore, in fulfillment of the brief detailed in the contract and in the MART PC1 the following research activities were carried out in cooperation between AZRI and ICARDA scientists:

1. Survey of cropping practices and perceptions of farmers engaged in rain-fed agriculture in upland Balochistan.

2. Collection, compilation and analysis of rainfall and temperature data of upland Balochistan.

3. Testing the potential of catchment basin water harvesting in upland Balochistan.

4. Testing the potential for improving crop productivity under rain-fed conditions in upland Balochistan:
   (a) wheat; (b) barley; (c) lentil and forage legumes.

5. Preparation of reports and publications based on 1-4 above, and presentation in national and international forums.

6. Organizing and conducting training workshops on: Agricultural statistics (4); The use of computers for agricultural data management and analysis (3); Water harvesting.

Reviews of various aspects of the research activities outlined above were presented by AZRI scientists at eight National and International Symposia/Workshops, and other aspects of the work were detailed in eight Research Reports. Five papers have also been prepared for publication in international scientific journals and their abstracts are presented in this report to encapsulate the principal scientific findings of the agronomy group.

1. AGROMETEOROLOGY

Precipitation and temperature regimes in upland Balochistan: their influence on dryland crop production.

Rainfall and temperature regimes for three contrasting locations in the 200 to 250 mm annual precipitation zone of upland Balochistan are described, and their implications for crop production discussed.

Rainfall dependability throughout upland Balochistan is generally low. Eastern and southern locations receive up to 40% of their rainfall during July and August, permitting October sowing of winter crops in six (Loralai) or seven (Khuzdar) years in ten. Western and northern locations receive little rainfall before December; in 50% of years sufficient rainfall for sowing cannot be expected before mid-January (Quetta). The spread of possible sowing dates is considerable: 53 days between dates at 0.25 and 0.75 exceedence probabilities at Quetta.

Rainfall receipt during spring is low in Khuzdar, so that crops have to survive mainly on residual

stored moisture. Cropping in this area is made possible by traditional water harvesting practices. Rainfall at Quetta is concentrated mainly in the months of January through March, so that considerable water stress frequently occurs in the grain-filling period. At Loralai rainfall is more evenly distributed, persisting until May in 25% of years. Water harvesting is also required to produce reasonable crops at these locations.

Mean maximum and minimum temperatures vary with elevation, ranging between 36 and -3 °C with 99 days below 0 °C at Quetta; between 37 and -2 °C with 67 days below 0 °C at Loralai; and between 38 and 3 °C at Khuzdar. Considerable temperature variations have been recorded with 25% of years with minimum temperatures of -10, -7 and -2 °C or less for Quetta, Loralai and Khuzdar respectively. The periods within which at least one frost could be experienced at 0.5 probability are also considerable: 161, 116 and 87 days, respectively, but the probability of a damaging frost during heading or anthesis is low.

Low temperatures at Quetta further restrict potential planting dates of spring crops, in contrast to the other two locations, where rainfall may occasionally permit spring sowing.

Upland Balochistan has one of the more severe climates for temperate crop production in West Asia, with low and undependable rainfall (partially relieved by water harvesting practices) and considerable cold stress at elevations above 1500 m. Cold-resistant, drought-tolerant winter crops are required for eastern and southern areas such as Khuzdar and Loralai, and drought-resistant, short-season crops for more western and northern areas such as Quetta.

Comments and future directions for research.

(a). The agrometeorology of upland Balochistan has now been described in some detail by AZRI, particularly the rainfall climatology of upland Balochistan. However, reliable recent rainfall data is currently available at AZRI for only three stations. Analyses have demonstrated that reliable conclusions can be made from the 1880-1946 data, but AZRI should now obtain, verify and compile the complete archive of rainfall for upland Balochistan for the period 1960 to 1990 from the Pakistan Meteorological Department. In addition to this, the complete temperature archive should be sought, and a detailed analysis of the temperature climatology of upland Balochistan should be carried out, to supplement the analysis already completed.

(b). AZRI's mandate dictates that it should also carry out dryland agricultural research for the other three provinces of Pakistan. Such data as is available for the Tharparkar and Cholistan deserts, the D. I. Khan-Bannu area, and perhaps for the dry regions of the Northern Areas (Gilgit, Skardu, Chitral) should be obtained, verified, compiled and analysed.

Two of the AZRI scientists are experienced in the use of the climate data management and analysis computer programs, but the final analysis stages would probably also require the services of a consultant trained in Agroclimatology as well.

2. WATER HARVESTING.

Catchment basin water harvesting as a means of improving the productivity of rainfed land in upland Balochistan.

Small catchment basins of different size were prepared within bunded fields on gently sloping silty valley bottom soils in upland Balochistan from 1985 to 1988. The ratios of catchment area to cropped area were 1:1 or 2:1. Seasonal rainfalls were 282, 102 and 239 mm in the 1985/86, 1986/87 and 1988/89 seasons, respectively.

Increased water storage in the cropped areas of 55% and 43% of the rain falling on the catchments were observed in the 1:1 and 2:1 treatments. Yields were considerably increased on a cropped area basis by the water harvesting treatments, but not always sufficiently to compensate for the loss of cropped land. The 2:1 treatments suffered from water-logging damage, even in the low rainfall year.

The cost of catchment set-up was low compared to the reduced seed and ploughing costs in the water harvesting treatments, resulting in 21 and 34% reductions in overall costs for the 1:1 and 2:1 treatments. Net benefits were 33% higher than the control for the 1:1 treatment overall, but 27% lower for the 2:1 treatment. Labour inputs were less for the water harvesting treatments, with the result that overall, returns to labour were more than doubled by water harvesting.

Within-field water harvesting with a 1:1 crop:catchment ratio thus reduced risk by reducing investments in seed, animal draft and labour, whilst maintaining yields, suggesting that it could be of considerable benefit to farmers in an environment with a high risk of crop failure. The potential for forming catchments on adjacent unused land, and further research aimed at reducing water-logging damage, could both lead to further improvements in farmer circumstances in upland Balochistan.

Comments and future directions for research.

(a). Water harvesting practices have been carried out in Pakistan for centuries in both upland and lowland Balochistan, and parts of NWFP, Punjab and Sind provinces, yet little research has been carried out on this topic in Pakistan. These traditional practices all fall within the general category of ephemeral stream diversion, but the size of the water course and the fields irrigated by the diverted water courses vary enormously, dependant upon topography. AZRI would appear to be an ideal vehicle for developing country-wide expertise in all aspects of water harvesting, perhaps overlapping with the soil and water conservation group of PARC. The recommendations of the participants of the Water Harvesting, Soil & Water Conservation Workshop held in Quetta and Islamabad encompass not only a range of research activities on water harvesting practices, but also data collection on the sociological and legal aspects of water harvesting, and outlines of training proposals. These recommendations could act as a blue-print for a group of sociological and physical scientists based at AZRI, but with country-wide activities and responsibilities. There is a strong case for assigning a senior sociologist and another senior agronomist with a strong background in soil and water conservation to a water harvesting group based at AZRI, to begin implementation of some of these recommendations.

(b). Water harvesting research for upland Baluchistan.

The catchment basin water harvesting research already implemented by AZRI shows considerable promise of reducing risks and increasing yields in crop production in upland Balochistan. Attention needs to be given to increasing infiltration and reducing water-logging in the cropped areas, and cropping strategies that reduce the risk of soil crusts reducing crop emergence. The use of soil conditioners to improve infiltration and reduce crusting should not necessarily be ruled out.

although these are likely to be costly. The use of spill-ways to allow egress of excess water seems perverse and unlikely to gain farmer acceptance except in circumstances where the land onto which any excess water spills belongs to the same farmer. The use of raised beds for crop production within the cropped area is in theory a much more attractive solution which would have relevance to the traditional stream-diversion water harvesting practises also.

AZRI should be involved in a detailed hydrological study of traditional stream-flow water harvesting in upland Balochistan, aimed at determining whether there is any practical way to improve the various traditional practices, which are excellent in some areas (Khuzdar, Mehtar) and poor in others (some of the areas between Quetta and Kalat).

3. IMPROVED RAIN-FED CROP PRODUCTION: WHEAT: USE OF FERTILIZER.

Dryland crop production in upland Balochistan.
1. Wheat (Triticum aestivum)

This paper is the first in a series evaluating the potential for improving crop productivity under rain-fed conditions in upland Balochistan. The results of three years trials on improved wheat management under rainfed conditions on farmers' fields in upland Balochistan are presented.

The soils (yermosols) are high in calcium carbonate content and pH, low in organic matter, nitrogen and phosphate content, and have textures ranging from sand-loams to clay-loams. Annual rainfall during the trials varied from 30 to over 350 mm with site and season, and seed yields from 10 to 620 kg ha^{-1}, averaging only 200 kg ha^{-1}. Economic net returns and returns to labour were low and highly variable, ranging from negative values to over 1000 R

ha^{-1} and 16 R $hour^{-1}$ respectively, and averaging only 304 R ha^{-1} and 2.3 R $hour^{-1}$ respectively.

The water use efficiency of the local wheat land-race was 9 kg ha^{-1} mm^{-1}, similar to other reported values. The wheat varieties recommended for irrigated conditions in upland Balochistan did not give substantially higher yields than the local land-race, and in 1986/87, the "good" rainfall year, gave substantially less yield.

Phosphate and potassium fertilization had little effect on yields. In the "good" rainfall year of 1986/87 nitrogen fertilization increased straw and seed yields of the local land-race by 29% and 24% respectively, but averaged over all trials the increased crop value was only 80 R ha^{-1} greater than the increased cost of production, and returns to labour were slightly reduced. Weeding also had little effect on crop yields.

In the arid conditions of upland Balochistan the economic net benefits and returns to labour of wheat production under rain-fed conditions are low and highly variable. Substantial improvements in wheat productivity are unlikely unless crop water availability can be increased on a sustainable basis.

Comments and future directions for research.

The rain-fed soils of upland Balochistan are amongst the poorest in Pakistan in terms of organic matter content and nutrient status, but water availability remains the major limiting factor. In almost all trials there were clear responses to fertilizer visible early in the season when moisture was available, and except in the high rainfall year of 1986/87, these responses were all reduced or non-existent by harvest-time, as a result of the over-riding effects of limited water availability. It is in the interests of AZRI and the career development of the scientists involved that research on response of rain-fed crops to fertilizer application in upland Balochistan should be **considerably reduced** and

restricted to **at most** one of the catchment basin water harvesting trials and one or two areas of **excellent** traditional water harvesting.

The recommended "improved" wheat varieties have failed to perform much better than the local land-race. This is also the case for the PARC recommended material, PARC 81. Any further effort should be restricted to those varieties provisionally selected by the AZRI Germplasm group.

4. BARLEY AND FORAGE LEGUMES.

Dryland crop production in upland Balochistan. 2. Barley (Hordeum vulgare).

This is the second in a series evaluating the potential for improved crop production under rain-fed conditions in upland Balochistan, in which the case for barley is examined. The growth and yield of a number of Syrian land-races and varieties were compared with that of the local land-race on farmers' fields under dryland conditions in upland Balochistan from 1985 to 1988.

Rainfall during crop growth varied from 32 to 220 mm, and grain yields varied from 10 to 1250 kg ha^{-1}, averaging 350 kg ha^{-1}. Seed and straw prices varied with season and availability, increasing considerably in the drought year of 1987/88. Economic net returns of the local land-race varied from negative values in 1987/88 to 1269 R ha^{-1} in the "wet" season of 1986/87, averaging 555 R ha^{-1}. The local barley land-race water use efficiency was 11 kg ha^{-1} mm^{-1}, and produced an average of 29% more yield than wheat when corrected for differences in water availability between trials.

The Syrian barley germplasm generally produced higher grain yields than the local, but with the exception of the land-race Arabi abiad, produced lower straw yields. Genotype-environment analyses indicated that Arabi abiad could be expected to produce more

grain, similar amounts of straw and higher gross benefits than the local in all environments except the most severe in which crop failure would occur.

Application of nitrogen and phosphate fertilizer increased yields in almost all trials, but the increases were sufficient to pay for the fertilizer in only one trial.

Net benefits and returns to labour were 24% and 16% higher for the Arabi abiad land-race than the upland Balochistan local land-race. There thus appears to be a reasonable potential for improving crop productivity in upland Balochistan, particularly if reliable crop-livestock production systems based on barley can be developed, in place of wheat production.

Dryland crop production in upland Balochistan.
3. Forage legumes.

This is the third paper in a series evaluating the potential for improved crop production under rain-fed conditions in upland Balochistan, in which the possibility of introducing forage legumes is examined. Seasonal feed shortages have been identified as a major constraint to livestock production in upland Balochistan and the introduction of dryland forage legumes capable of producing relatively high protein content straw presents one possible solution to this problem. The growth of three new introductions of Vicia species was observed on farmers' fields from 1985 to 1988, and these were compared with the local lentil (Lens culinaris) land-race as a control treatment.

In 1985/86 and 1987/88 lack of rain delayed emergence until mid-February, with the result that the crops were subject to considerable water stress but not to cold stress in these years. In these conditions there were little differences between the Vicia species. In 1986/87 rainfall was much higher,

permitting autumn sowing, and the crops were subject to considerable cold stress during the winter, and to moderate levels of water stress. V. narbonensis was severely damaged by cold and V. sativa somewhat less so. V. villosa ssp. dasycarpa produced much higher straw and seed yields (2780 and 600 kg ha^{-1}, respectively) than the lentil (1280 and 490 kg ha^{-1}, respectively) or the other Vicia species in these conditions. Inoculation with Rhizobium leguminosarum produced large yield increases in three of the four trials in this year (22 to 120 percent).

Averaged over all trials, V. villosa ssp. dasycarpa produced higher herbage and straw yields, and similar seed yields to the lentil control (1410, 1160 and 230 kg ha^{-1} respectively, compared to 920, 650 and 240 kg ha^{-1}). The water use efficiencies of the lentil and V. villosa ssp. dasycarpa were similar: 5.1 and 4.9 kg ha^{-1} mm^{-1} respectively. The crude protein content of V. villosa ssp. dasycarpa herbage and straw, nine and seven percent, and its good yield potential in the arid conditions of upland Balochistan suggests that this species would be a useful introduction into the dryland farming system of upland Balochistan as part of a sustainable crop-livestock production system.

Comments and future directions for research.

An exotic barley land-race and an exotic forage legume both well adapted to upland Balochistan and capable of increasing productivity have been identified. However, the farmers of upland Balochistan do not normally give much attention to these crops. The major emphasis with these crops should now be on integrated crop-livestock production on farmers' fields in cooperation with farmers, rather than on more traditional agronomy experiments. The focus should be on identifying farmer attitudes to crop production for animal feed and devising an integrated scheme that is acceptable to the farmers. Close cooperation with livestock scientists and social scientists is required to determine organic matter digestibilities of the crops at different stages for planning appropriate rations; to evaluate

local animal management practises; to integrate strategic supplementation with **locally produced crop products** and range-grazing; to evaluate the increased risk, and potential increased profitability or subsistence production, of growing crops for improved animal production rather than for sale or subsistence, etc. There is considerable theoretical potential for producing barley and forage legume hays; the costs of manually harvesting and storing such hays, and the nutrient losses during these activities, need to be evaluated.

FUTURE RECOMMENDATIONS FOR TRAINING.

(a) Economic evaluation of results. All the crop, range and livestock scientists of AZRI urgently require further exposure to, and training in, the principles of partial budgeting, with particular emphasis on integrating the concept of production costs into their work. Increased production of crops, grasses, shrubs and livestock will be of little value if the costs are beyond the means of the client group.

(b) Other topics. The crop scientists of AZRI require further training on stability analyses (mainly genotype-environment type analyses) and on plant-soil water relations.

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GERMPLASM EVALUATION

INTRODUCTION

In the period 1980-85, the germplasm evaluation group was actively collaborating with ICARDA in particular in the search for breadwheat and barley cultivars resistant to rust diseases and the wider introduction of food legumes to upland Baluchistan. The MART/AZR contract and MART PC1 documents stress the need for a long-term evaluation of cereal, food legume and forage germplasm in terms of disease and environmental stress resistance over the range of ecological conditions experienced in upland Baluchistan. This activity was therefore in support of the ongoing AZRI/ICARDA collaborative program.

The report of the National Commission on Agriculture, 1988 has reflected the AZRI view that at present the very large arid rainfed areas of upland Balochistan (>1000m) are a much underutilized agricultural resource due to its harsh and variable climate. Considerable forethought is thus required to plan a germplasm selection and breeding strategy to identify appropriate crop genotypes which can provide a more consistent and rewarding agricultural productivity from both food and forage crops in this highly variable environment. In response, in the period 1985-89 AZRI has employed a somewhat unconventional germplasm evaluation program in upland Balochistan which has yielded a measure of success and is described below.

RESEARCH STRATEGY

Germplasm evaluation research emphasizes the need for a better understanding of yield limiting factors imposed by the varying environmental and biotic factors in the major agro-ecological zones of upland Balochistan. Crops currently under evaluation are bread wheat, barley, lentils and forage legumes (mainly annually sown). The program makes use of multi-location testing and different times of sowing to identify genotypes that are either widely adapted or adapted to specific ecological conditions. This allows the selection of genetic material with increased yield and stability of production when exposed to recurring stresses such as drought, cold, heat and diseases. The specific objectives of the program are:

1. The selection of improved disease resistant crop genotypes suitable for growth under non-irrigated conditions to diversify the present wheat monocropping system in upland Balochistan; and,

2. Investigation of the potential for additional livestock feed production from either the introduction of new forage crops or from the additional crop residues from food or dual purpose crops.

Three principal locations Quetta (Que, altitude 1750m, latitude 300 14'N, longitude 670 2'E), Khuzdar (Khu, altitude 1250m, latitude 270 46'N, longitude 660 39'E) and Kan Mehtarzai (K.Meh, altitude 2250m, latitude 670 45'N , longitude 310 00'E) have been used for multi-year testing. These sites largely cover the range of climatic environments experienced in the cropping areas of upland Balochistan.

Seeding times are determined by the alternative practices of local farmers. Thus, the first seeding time is in Autumn (late September or early October) if summer monsoonal rains occur (approximate recurrence 1-2 years in ten at Quetta and more frequently at the other sites). If they do not,

irrigation is applied to simulate this condition to allow pre-winter emergence and thus cold screening of material on an annual basis. The second seeding time is in spring (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 rate of 60 kg/ha N and 60 kg/ha P_2O_5 in the case of cereals and in the case of legumes rhizobial inoculation plus 60 kg/ha P_2O_5.

CLIMATIC CONDITIONS

The climatic conditions in upland Balochistan are highly inconsistent. Years of 250mm precipitation or less are common. Furthermore rainfall is often not well distributed throughout the year. Most of the rain occurs in winter but important summer monsoonal rain is also experienced inconsistently. Late rainfall in winter may delay the emergence of winter crops due to low air temperatures experienced at altitudes above 1300m in December and January. High air temperatures in early summer, in the absence of rainfall, may become an important factor in hastening crop maturity.

The severity and variability of the temperature and rainfall regimes at the three experimental sites between 1985 and 1989 is shown in Table 1. The 1985/86 season at Quetta may be regarded as having been poor and dry because rains were received late and these were badly distributed.

The 1986/87 and 1988/89 seasons were the most favourable growth years of the four described with important pre-sowing showers of late monsoonal rains. More than average rainfall was received in 1986/87 and 1988/89 (Table 1). In contrast the 1987/88 season was very dry with totals being well below average at all sites.

The 1986/87 season was the coldest season at all locations with the exception of Khuzdar where lowest temperatures were observed during the season of

1988/89 (Table 1). An unusual event was also observed during the 1988/89 season at all the experimental sites when air temperature suddenly fell to below zero in the first week of May, 1989, which severely affected the seed formation process and had a serious impact on overall grain productivity.

Table 1. Total rainfall (mm) and extreme daily air temperatures °C during the crop growth seasons 1985-1989.

	Rainfall			Min. Air Temp.			Max Air Temp.		
	Que	Khu	K.Meh	Que	Khu	K.Meh	Que	Khu	K.Meh
1985/86	202	*	*	-7	*	*	36	*	*
1986/87	238	86	170	-16	0	-19	37	41	33
1987/88	148	27	66	-6	-1	-12	38	40	32
1988/89	213	45	222	-8	-8	-13	39	40	33

* These locations were not included in the programme in 1985/86.

ACHIEVEMENTS

1. Wheat

One superior bread wheat line has been identified for winter planting to date (Figure 1). This line has genetic resistance to disease stress particularly yellow rust. This line has also shown better productivity in comparatively dry years than the local landrace and has a sufficiently high level of cold tolerance for winter planting.

At present farmers only have a very limited choice of wheat varieties for spring planting. They often also plant the winter type landrace in spring, but with little likelihood of obtaining grain yield. Ten different genotypes have been potentially identified to date suitable for this shorter maturity period (Figure 2).

2. Barley

Barley is generally regarded to be a crop more adapted to drought stress than wheat. In upland Balochistan there is therefore a good chance of increasing barley production from its current highly subsidiary position to that of wheat by the identification of drought resistant genotypes. Five such barley genotypes have been selected for upland Balochistan. Among them, Arabi abiad has been selected for both winter and spring plantings. Arabi abiad is more drought tolerant than the local landrace. It gave significantly higher grain yield in dry environments when compared with local barley. Arabi abiad is slightly better than local barley in winter planting but significantly better in spring sowing (Figure 3, 6). The other winter type selected line is 39-58. This line has the genetic ability to perform moderately well in dry environments and also is more productive in favourable conditions (Figure 4). All these winter type selected genotypes have a prostrate winter growth habit, early growth vigour in spring and early maturity when compared to the local barley landrace. Winter type genotypes selected require sufficient flexibility of cold tolerance to

FIG.1 HIGH YIELDING WHEAT LINE SELECTED FOR WINTER PLANTING IN UPLAND AREAS DURING 1986–89 (AVERAGE OF 8 DIFFERENT ENV.)

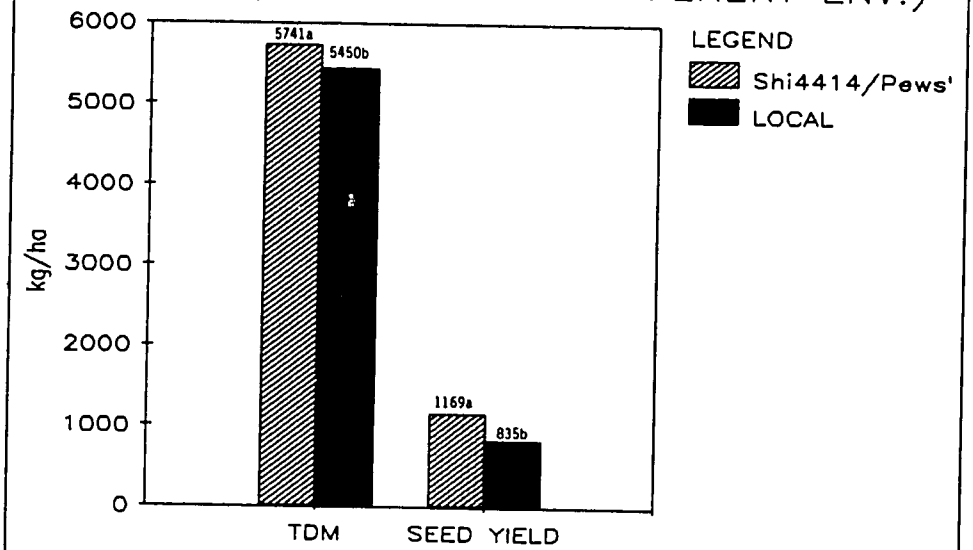


FIG.2 HIGH YIELDING WHEAT LINES SELECTED FOR SHORT MATURITY DURING 1986–89 IN UPLAND BALOCHISTAN (AV. OF 7 ENV.)

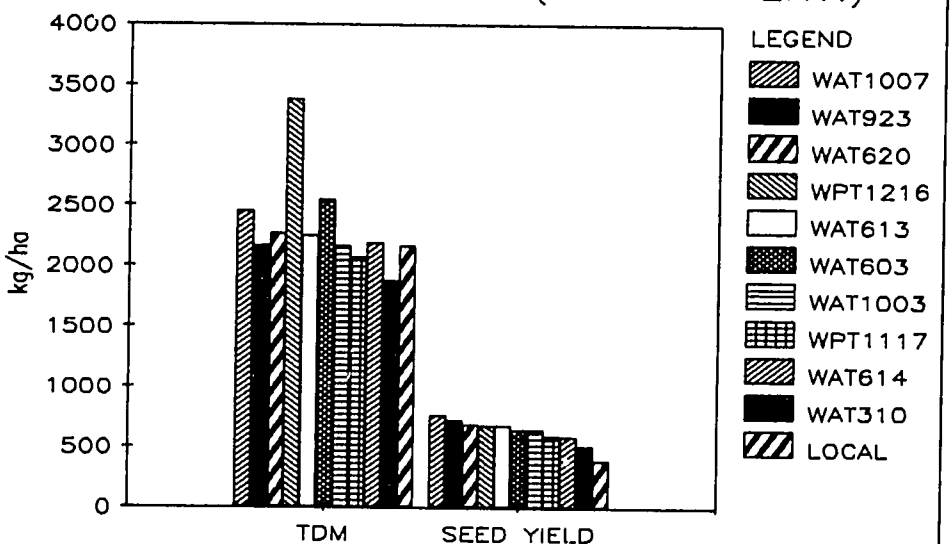


FIG.3 ARABI ABIAD IN COMPARISON TO THE LOCAL BARLEY IN DRY ENVIRONMENTS IN UPLAND BALOCHISTAN (AVERAGE OF 3 DIFFERENT ENVIRONMENTS)

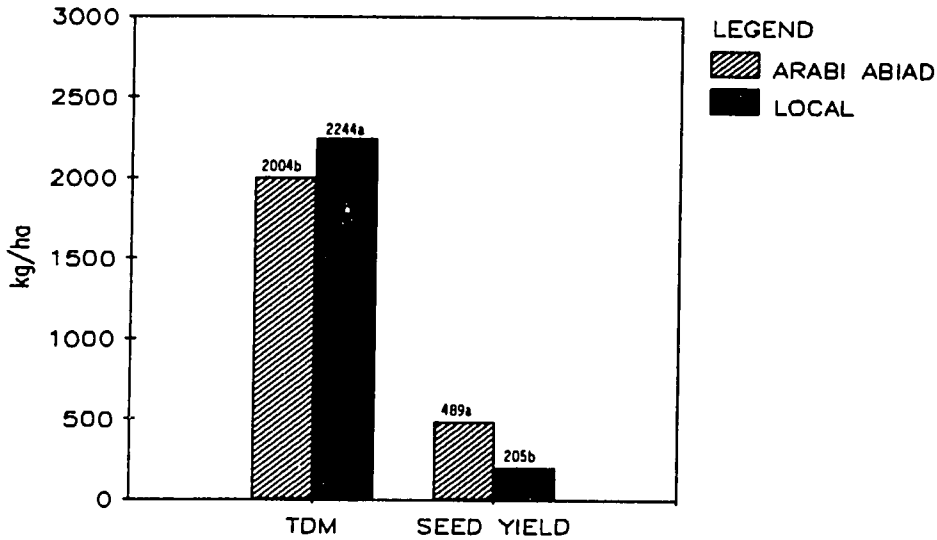
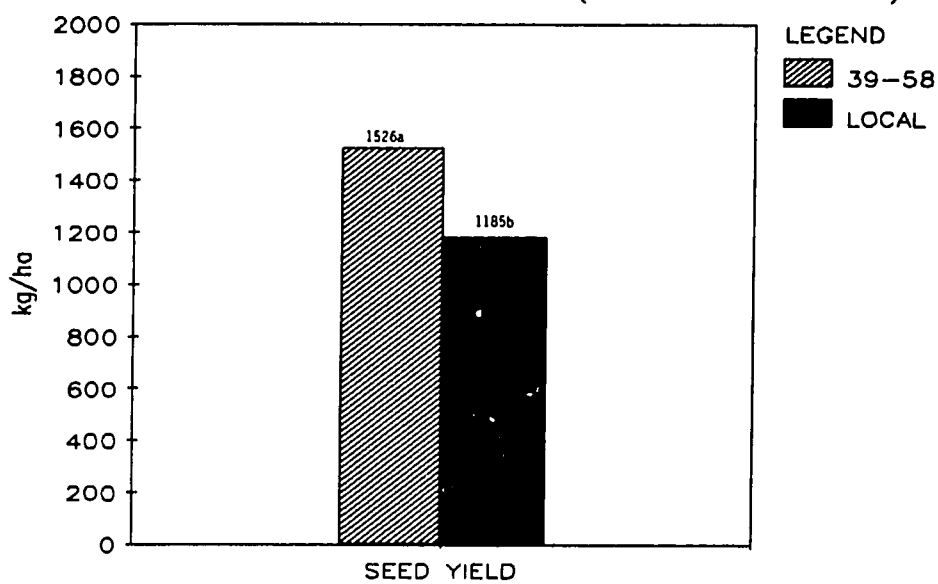


FIG.4 HIGH YIELDING BARLEY LINE SELECTED FOR WINTER PLANTING DURING 1987–89 (AV. OF 4 ENV.)



acclimatize to upland environments ranging from 1500m to 2300m.

Three genotypes selected for spring planting have the characteristic of earlier maturity than the local landrace, and thus should allow them a better chance of escaping terminal drought. These genotypes are also higher yielding and more disease resistant than the local landrace (Figures 5 and 6).

3. Forage Legumes

Forage legumes were included in the AZRI testing programme for the first time during the 1985/86 season. To date Vicia and lathyrus species have been tested. The genotype Vicia villosa ssp. dasycarpa has been found to be outstandingly productive in comparison to all other genotypes across a range of locations and seasons (Figure 7). It is a genotype of indeterminate maturity period with enhanced cold tolerance and gives better production when sown in autumn (Figure 8). When spring sowing is the only option for farmers, Lathyrus sativus may be the genotype of choice (Figure 8). This genotype is not cold tolerant and has a better chance of survival if only planted in spring. Vicia ervillia may be another possible genotype for spring planting or for winter planting in warmer locations (<1300m). Both these genotypes are very drought tolerant and have reliable seed setting characteristics in dry years. In contrast, Vicia dasycarpa is much more productive in comparatively good environments, but in dry years though it has good hay yields it has poor seed production. Vicia sativa, the most commonly grown vetch species in west Asia is neither very drought nor cold tolerant. It may be more suitable for less extreme environments (Figure 8).

4. LENTILS

Lentils were included for the first time in the programme during the 1984/85 season. However none of the material was suitably adapted and during the first two experimental seasons no selections were made. Collection of material continued and during

FIG.5 HIGH YIELDING BARLEY LINE WITH SHORT MATURITY PERIOD SELECTED FOR UPLAND BALOCHISTAN DURING 1986–89 (AV. OF 7 ENV.)

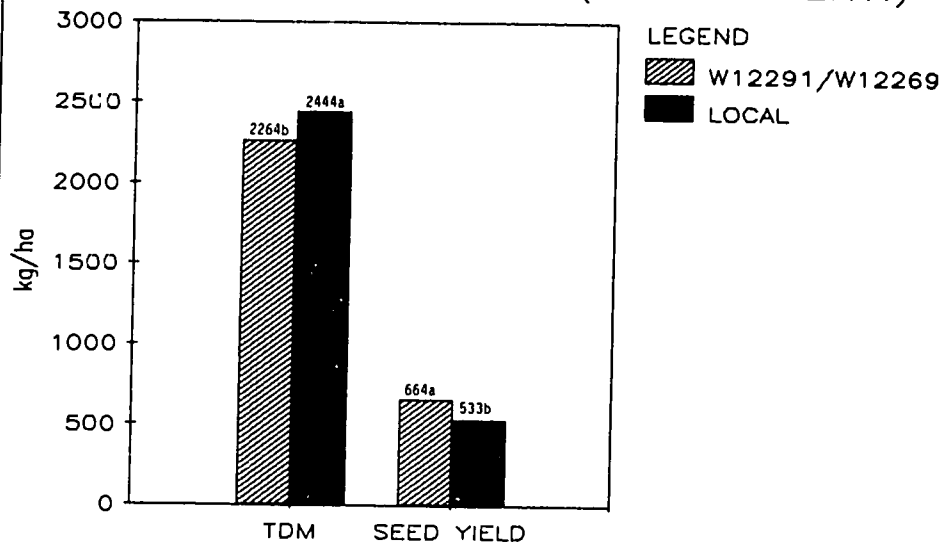


FIG.6 HIGH YIELDING BARLEY LINES FOR SPRING PLANTING IN UPLAND BALOCHISTAN SELECTED DURING 1986–89 (AV. OF 5 ENV.)

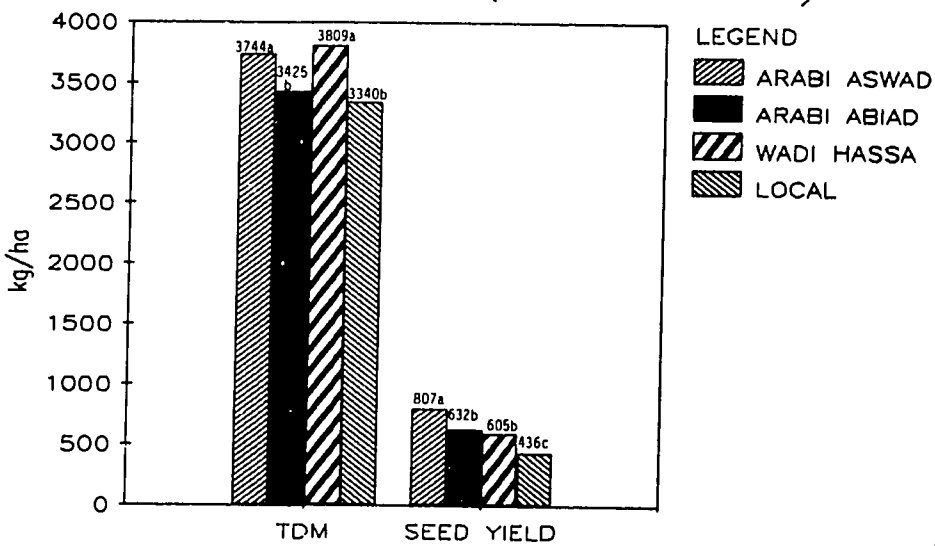


FIG.7 HIGH YIELDING GENOTYPES OF FORAGE LEGUMES SELECTED DURING 1985–89 AT THREE LOCATIONS (>1000m) WITH TWO PLANTING DATES (AV. OF 19 ENV.)

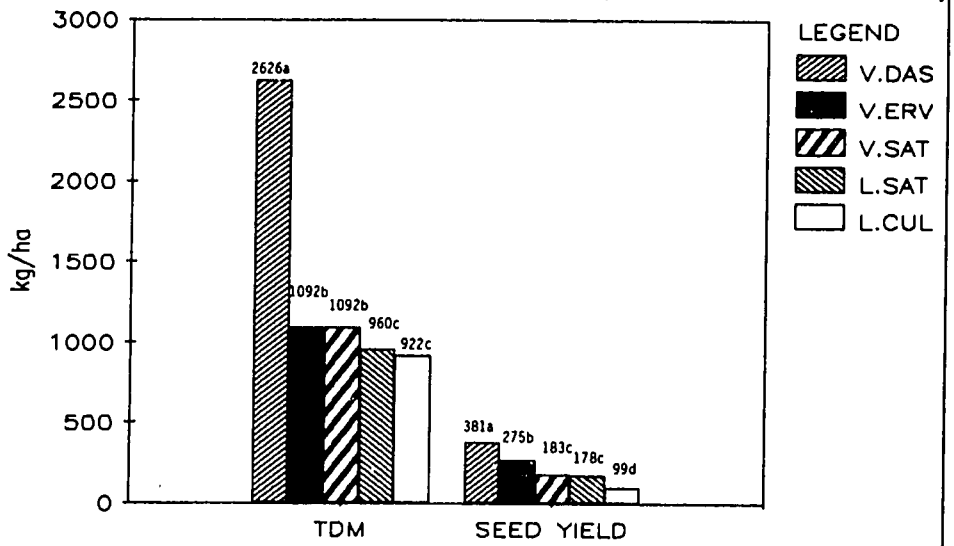
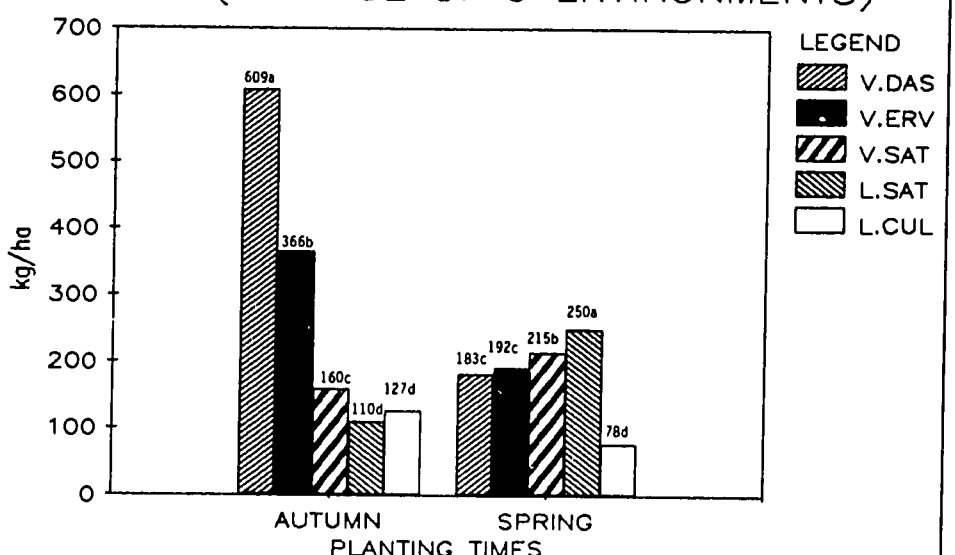


FIG.8 SEED YIELD OF SELECTED GENOTYPES OF FORAGE LEGUMES (1986–89) WITH TWO DIFFERENT PLANTING TIMES (AVERAGE OF 9 ENVIRONMENTS)



the 1986/87 season superior material was selected for the first time. Disease free, bold seeded, high yielding lentil lines are the principle selection target. The local landrace is quite productive but is susceptible to wilt and is ultra small seeded. This can often result in a poorer market price.

Two bold seeded lentil lines have been identified which outyield the local landrace and are wilt resistant (Figure 9). These lines appear to be as widely adapted as the local landrace over the range of environmental conditions found from 1250 to 2300 m. However, though the selected lines are slightly less cold tolerant than the local landrace they show good regrowth ability following upper foliage frost burn when temperatures, normal for vegetative growth, are experienced in spring.

One of these selected lines ILL 5865 has been found to be significantly ($P<0.05$) higher yielding than the local landrace in drier environments in particular. This is an encouraging pointer to its width of adaptability in upland Balochistan (Figure 10).

All the lentil lines selected to date are of the longer maturity group similar to that of the local landrace and are particularly fitted for winter planting. Material of a shorter maturity period which could be planted in spring has yet to be identified. This would permit farmers the choice of planting lentils in both the normal times of planting in upland Balochistan.

Comment and future directions for research

All the local landraces, of different crop species under evaluation, are of the longer maturity type. A breakthrough can perhaps be made by identifying more genotypes of shorter maturity type with high yield potential. To date AZRI has had some success in finding adapted genotypes of shorter maturity period in wheat and barley but not in lentils and forage legumes. So, in future more emphasis will be given to finding material with

FIG.9 HIGH YIELDING LINES OF LENTILS SELECTED DURING 1986–89 AT THREE LOCATIONS (1250–2250m ALT.) WITH TWO PLANTING TIMES (AV. OF 18 ENV.)

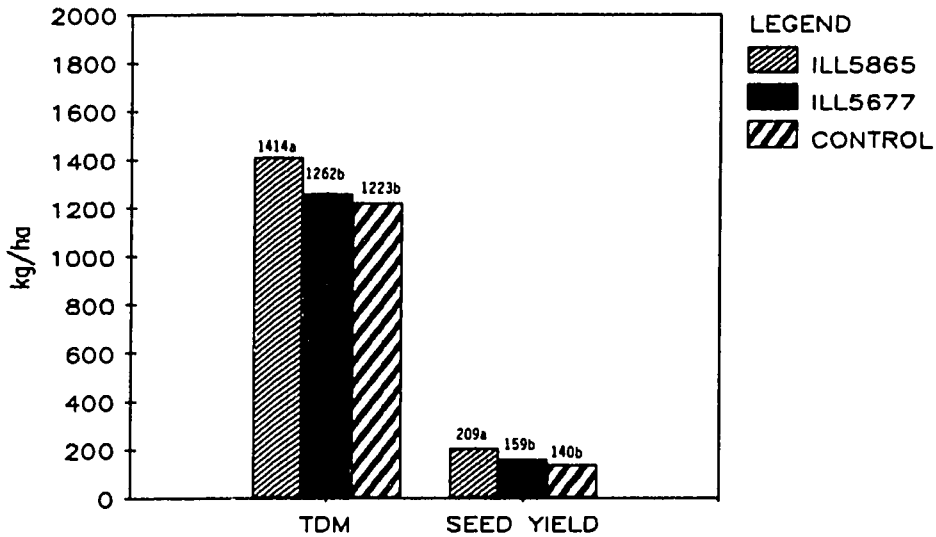
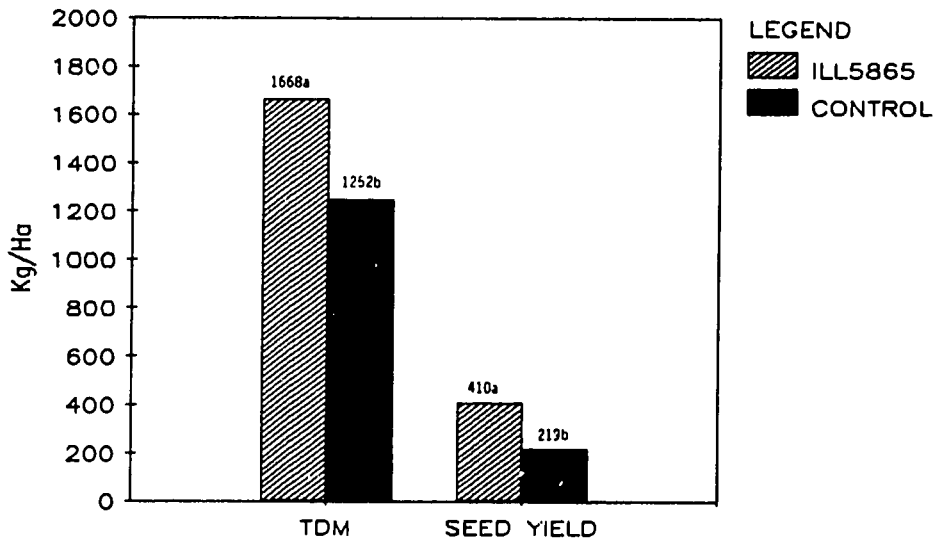


FIG.10 ILL 5865 IN COMPARISON TO THE LOCAL LANDRACE IN DRY ENVIRONMENTS IN AUTUMN PLANTING (AV. OF 3 ENV.)



shorter maturity period in these legumes. In addition, material will be sought with improved seed setting characteristics in the presence of severe terminal drought. This is currently a problem in adapted Vicia villosa forage lines.

In contrast, for cereals emphasis will shift towards finding more material of longer maturity winter type to broaden the currently available genetic base. This will be in preparation for an expected increase in the number of years in which winter planting will be possible following the adoption by farmers of AZRI catchment basin water harvesting systems.

Disease resistance in cereals has not yet had adequate testing under field conditions in upland Baluchistan owing to the almost complete absence of disease during the period reported. However, the epiphytotic conditions experienced twice in the early 1980's have not been forgotten, and continued germplasm evaluation is required, hopefully, to forestall or reduce the impact of a future occurrence of environmental conditions conducive to diseases in epidemic form.

If farmers can have a greater choice of disease resistant varieties of crop and maturity class suitable for the variable environment of upland Balochistan, they will be able to reduce the substantial risks of crop failure that they currently experience. Greater and more sustained productivity will hopefully then be possible from dryland crop production in upland Balochistan. This in turn may permit greater security of available animal feed and thus an improvement in sustained animal offtake.

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AGRICULTURAL EXTENSION

INTRODUCTION

The agricultural extension adviser became a member of the MART/AZR team at AZRI in October 1986. This delayed start was in accordance with the contract and MART PC1 recommendations which envisaged an almost immediate function of technology dissemination. However, in retrospect the job description in the contract was not appropriate for the development of a suitable work program as unfortunately, AZRI was not ready to deliver relevant and proven technologies to its target population in 1986 and is in fact only beginning to reach this particular phase of research maturity in late 1989.

Prior to 1986 AZRI did not have an active extension group therefore no available experience existed within the Institution which could serve as a basis for program development. Moreover, expertise and experience in extension were also largely lacking in the main research partners in the MART/AZR project, PARC and ICARDA, as neither Institution currently has a mandate for extension. The program had therefore to be developed from first principles. The AZRI extension program has consequently been continuously developed and revised in the last three years through deliberate evaluations of the options and constraints dictated by circumstances within and beyond AZRI and the PARC system.

The AZRI extension program can be divided into three distinctive but interrelated parts; (a) field activities, (b) extension research and (c) information transfer and media production.

1. FIELD ACTIVITIES

Framework

An extension group in a research institute performs a basic technology transfer function and additionally can contribute to technology generation. The AZRI extension group efforts were focused on the latter area of work because of the lack of AZRI technologies ready to transfer.

This role of contributing to AZRI technology generation and evaluation was mainly performed through field activities in the extension program. We have developed a list of "justification indicators" for our field activities which are as follows:

(a) Extension group field activities are not an adjunct at the end of the research process. They are an integral part of AZRI's technology generation and evaluation efforts and represent a logical sequence in the technology generation and transfer continuum. They ensure farmer participation in technology evaluation. As an integral part of AZRI research they are designed and evaluated in collaboration with related AZRI research groups.

(b) Extension group field activities can be helpful in fulfilling a classical function of extension, namely to provide feedback information to biological researchers in AZRI about farmers goals, problems and constraints. This information can be helpful in prioritizing AZRI research programs to address farmer needs.

(c) Extension group field activities ensure the active participation of the provincial extension agencies in AZRI's research efforts as stressed by the MART PC-1. This participation can enhance AZRI's technology evaluation efforts and in turn can create a commitment to the transfer of AZRI technologies by the participant extension agency. Therefore, field activities should cover at least one subject closely related to each of the three existing extension agencies in Balochistan; Agriculture, Livestock and Forestry.

(d) Extension group field activities enlarge our understanding of the sociocultural characteristics of rural communities through working experience in real life situations. This understanding can be very valuable in identifying appropriate strategies and methods for effective technology transfer.

Achievements

The extension group field activities have consisted of: (a) Farmer managed trials, (b) mobile veterinary aid camps and (c) multipurpose tree and range shrub evaluation/introduction trials.

Farmer managed trials were organized to assess the management practices and abilities of farmers which are an important variable in technology evaluation. To obtain the farmers own assessment of the interventions being tested was regarded as being of primary importance. Farmers meetings throughout the season, and post harvest cooperative farmer surveys, were conducted. The first years trials included variety and fertilizer application as interventions in wheat production. Detailed results were published in MART/AZR Research Report 12. The second years trials were effectively a failure as grain formation did not take place due to inadequate rainfall. In the third year emphasis was shifted in parallel to that of the agronomy group research program, thus forage crop evaluations was undertaken. Barley (local and Arabic abiad) and a forage legume, Vicia villosa ssp. dasycarpa were tested. Local wheat was added as the control treatment to allow farmers to make a comparative assessments of the three species.

During the three year period of extension group activities 10 mobile veterinary aid camps were organized in collaboration with the provincial livestock department. The number of animals vaccinated and drenched was around 70,000. Excellent cooperation was received from the management of the Livestock Department and their local veterinarians and stock assistants in the Mastung and Kalat areas. The concept of using veterinary camps as a vehicle for livestock extension was discussed thoroughly and this is an opportunity for further AZRI cooperation with the Livestock Department. For example, in cooperation with AZRI range/livestock section a survey on internal and external parasites was conducted at a camp site (MART/AZR Research Report 13). Furthermore, in cooperation with PTV and PBC several TV and Radio programs were produced on the spot at these camps which highlights their potential function as vehicles for agricultural extension.

More than 5,000 Mulberry saplings were planted in the Kovak Valley, either in blocks or in homesteads by farmers. An ongoing survival and performance trial is being conducted which consists of species such as Local Mulberry, Eleagenus herbasus, Alianthus angustifolea, Robinea pseudocacia, and Prunus eburnea. These multipurpose tree trials are a cooperative effort with the local Forestry Department, Mastung Office. Fourwing saltbush (Atriplex canescens) seedling transplant evaluation/introduction trials are under way presently in farmers fields at Gajan and Mollazai villages in the Kovak Valley.

Constraints

The staffing position and specific training of staff in the extension group was never at a level to permit a full range of field activities. There were only two scientific officers from the biological sciences in the extension group both agronomists (one left very recently for long term training). However, if a full contribution to technology evaluation is expected from the extension group staff then a greater range of staff skills in the biological sciences would have been much more appropriate.

Cooperation with provincial extension agencies has been obtained on the basis of personal initiatives because of the lack of a formal agreement between AZRI and the Provincial Departments for field level cooperation. This lack of formal cooperation is not principally a reflection of the lack of desire of these agencies to cooperate but rather is a consequence of their divergent mandates. For example, the Agricultural Department is at present only marginally interested in dryland agriculture. It is hoped that the interest could be developed and maintained once AZRI's new echnologies come on stream.

A better internal understanding and commitment to extension group functions is also required within AZRI. Unfortunately, even after three years active canvassing of biological scientist at AZRI on behalf of the value of extensionists in technology evaluation, we have not been entirely successful in convincing them of the logic of our case.

Future Directions

If AZRI continues to have an extension group in future, field activities are inevitable. Extension groups can not thrive without field exposure. After three years experience, in my judgement, there are multipurpose benefits to be derived from such activities. Foremost, without farmer-managed trials, the AZRI research process may remain incomplete as the provincial extension agencies have only limited ability, to turn research results into sound extension recommendations. A sound extension recommendation not only defines the technology that will be transferred but also, carries information on where it should be transferred and to whom it should be transferred . The AZRI extension group, therefore, through multilocational farmer-managed verification trials, has an important role in bridging the gap between the information produced by the researcher managed on-farm trials and the information needed for technology transfer to farmers.

Future recommendations:

(a) **Water harvesting farmer managed trials** should be initiated in the field activities program of the AZRI extension group besides their current continuing activities on promising forage crops, multipurpose trees and Atriplex canescens.

(b) The extension group should undertake the responsibility for testing and obtaining farmer responses to the **camel drawn planter** developed by the agronomy group.

(c) The experiences from mobile veterinary camps should be used in a **pilot livestock health extension campaign for disease and parasite control** in collaboration with the Livestock Department.

2. RESEARCH IN EXTENSION ISSUES

Framework

In the absence of experience and a prescriptive extension model, the premier responsibility of extension research is to provide a better understanding of the socio-cultural setting into which dryland technologies will be introduced.

In the context of dryland agriculture, an extension model to fit into the clients social system and available extension sources needs to be developed based on research studies.

Extension research at AZRI should be locale specific and problem oriented thus assisting policy makers and extension service managers by determining methods of extension and communication suitable for dryland agricultural extension.

Extension research should produce relevant information which local extension workers can use directly in their extension activities and which can be used to enhance the in-service training of extension workers.

Achievements

An anthropological field study was conducted, by a short term consultant for the extension group, in the rural areas particularly where AZRI on-farm research activities were being carried out. This study is aimed at providing community profiles which described the historical background, ethnic composition, natural resource base, patterns of interaction and leadership among the members of the farming community. This study is reported in MART/AZR Research Report 11.

An agricultural extension survey was conducted to investigate; (a) selected social characteristics and attitudes of farmers, (b) indigenous communication patterns and factors influencing the flow of communication within and between rural communities, and (c) local and institutional sources of agricultural information. Recommendations were made for appropriate extension approaches and methods based on these data. MART/AZR Research Report 30 was produced from the results of the extension survey.

Constraints

The extension group had only one extension-education graduate S.O. in its team. There is an urgent need for more extension scientists at AZRI, particularly those with knowledge of local languages and familiarity with rural culture.

Future Directions

As a rule, problem-solving extension research should be undertaken by the organizations who are closest to where extension operates. AZRI seems to have an advantageous position compared to educational institutions and the provincial extension agencies to undertake the responsibility of extension research in Balochistan for the following reasons:

(a) The report of the National Commission on Agriculture recommends that universities should have a larger role in extension and "research in extension" is given as the first task for universities. Balochistan is the only province in Pakistan which hasn't an agricultural university currently. Therefore it is out of the question for extension research to be undertaken in an educational institution in Balochistan. It is hoped that this needed research will be included in any future plans for upgrading the Balochistan agricultural college to university status.

(b) Provincial extension agencies in Balochistan are separated into crop and livestock husbandry administrative units in which dryland agricultural extension currently

has low priority. The Forestry Department has no extension service per se.

(c) Therefore, if there is a need for extension research in the context of dryland agriculture in Balochistan I belive AZRI, as a capable research institute with a broadbased approach to dryland agricultural research, is the right place to undertake extension research to serve the provincial extension services.

Recommendations for future AZRI research program in extension issues.

(a) The farmers frame of reference and local practices must be well understood by extension workers for the effective transference of scientific knowledge. A special study has already been planned to examine "folk knowledge and treatments in animal health." This study will be aimed at collecting data on local knowledge of diseases affecting small ruminants, the chain of causality which animal owners recognize concerning the occurrence of disease, local treatments and medicines, and farmers' attitudes towards veterinary services. In addition, a glossary of Brahui and Pashto terms in animal health will be produced.

(b) The extension survey revealed that agricultural fairs constitute the only forum where dryland farmers have broad scale access to institutional information. An evaluative study was planned last year and a questionnaire was developed to obtain data to help discern methods of improving the effectiveness of the Sibi Show as an extension vehicle. The cancellation of the show made it impossible to conduct this study, however the same questionnaire will be used in 1990.

(c) New research projects are needed to better understand the flow of agricultural information and local communication networks. "Seed exchange" seems to be a suitable tracer factor which can be used as a means of identifying how information flows within and between rural communities.

(d) Changing patterns of transhumancy and land tenure should be monitored by suitable research studies. Changes in farmers' access to off-farm employment opportunities should also be recorded. Cooperation with the economics group at AZRI and ARI Sariab is required in designing and implementing these studies.

(e) Farmers practices and perceptions in soil moisture conservation, bund establishment and water harvesting need to be better understood in order to pave the way for the AZRI improved water harvesting technology under investigation.

(f) The multipurpose tree establishment activities of the extension group in the Kovak Valley needs to be supported by a further survey on farmer practice with regard to planting and maintaining saplings, and their expectations for future utilization of these trees.

(g) In a few years extension research at AZRI should shift its focus on to second generation studies such as: (i) monitoring of farmer adoption of AZRI generated technologies, (ii) organization and management of extension services and (iii) pre-testing and effectiveness evaluation of communication media in agricultural extension.

3. INFORMATION TRANSFER AND MEDIA PRODUCTION

Framework

Generation of new knowledge can become a social benefit only if that knowledge can be effectively transferred to those who both need and will use it. While the ultimate beneficiaries of AZRI research activities are dryland farmers, the clients of AZRI-generated knowledge include research colleagues, extensionists, planners and policy makers. The AZRI extension group has wide ranging responsibility to ensure accessibility and effective transfer of information to those diverse users.

The extension group can assist AZRI management and scientists to identify what kind of information should be transferred and what kinds of communication mode are required to meet the needs of specific groups of users.

The extension group can assist AZRI management and research groups in designing, organizing, executing and evaluating training programs, workshops and seminars.

The extension group can support provincial extension services by providing in-service training for their staff in extension and communication issues.

These responsibilities require a range of communication media production and utilization such as:

(a) To produce "extension media" to promote AZRI generated technologies. The cooperation and endorsement of the technology transfer agencies that will actually use these media in their extension programs is required. Principle vehicles should include, audio and video cassettes, posters and radio programs.

(b) To produce A/V material and training aids to serve the needs of AZRI scientists in scientific presentation. The production of self-tutorial training materials is included in this area of responsibility. Principle forms should include, slides, transparencies and written texts.

(c) To produce communication media for the transference of AZRI generated knowledge and acquired dryland agricultural information in a timely fashion for research and extension colleagues, and policy makers. Principle forms should include research reports, bulletins, newsletters, library information services.

(d) To produce communication media to introduce and promote AZRI's activities and achievements to increase its credibility; and thus to obtain support from policy makers, donors, development agencies and the general public. Principle media vehicles include mass media programs, displays, giveaways and newsletters.

The extension group undertakes the responsibility of the development of the AZRI library/resource center.

Achievements

Three provincial level training workshops and one national seminar in extension issues have been organized by the extension group. Assistance was provided in mass media relations and communication media production for the national seminars organized by the other AZRI research groups.

AZRI has begun to participate regularly at provincial agricultural fairs and at the NARC Open House in Islamabad.

Mass media coverage was provided on the main activities of AZRI through the efforts of the extension group in releasing press bulletins and organizing press conferences. Several extension group field activities have been visited by TV and Radio staff and on-the-spot programs were produced and broadcast.

An A/V unit has established and assistance in A/V materials for AZRI scientists has been provided. AZRI activities have been documented on video tape.

Constraints

Information transfer and media production activities require a wide range of professional skills. We faced continuing demand for media production without having an editor, producer, graphic artist, script writer, etc. The only professional we have is a photographer. Under these circumstances we spent too much time on activities for which we had not been professionally trained.

The AZRI library today has improved in terms of (a) its contacts with dryland agricultural research organizations globally, (b) classification and cataloging systems, and (c) number of books and journals purchased. In addition, we released three library acquisition bulletins. However, the AZRI library is still not more than a modest collection of written materials. We strongly need more experienced

staff, proper equipment, and an adequate purchase and subscription budget to acquire books and journals.

Future Directions

Parallel to improvements in quality and quantity of research work in AZRI, there will be a growing need for information transfer and media production activities. Therefore AZRI should develop its capacity in a planned and balanced manner both in manpower and equipment. Without adequate staffing there will be inevitable wastage of time and money, for what might be an ineffective communication medium. Parallel to capacity development my suggestions are as follows:

A periodic AZRI newsletter, regular radio programs, a multivision display, giveaway brochures and training materials are priority areas for AZRI action.

Communication technology should be used, not only for instructions to farmers, but in innovative bottom-up fashion in order to create awareness and interest in dryland problems among policy makers, research colleagues and the general public. For example, documentary video films on rangeland degradation, on parasite infestation, or on farmers risk management practices would be very valuable. I also support the idea of farmer to farmer programs in both radio and in audio cassettes.

Organizing "farmer days" in major AZRI research sites is highly recommended.

The library/resource center's development is of utmost importance and urgency. A development plan should be prepared by a short term consultant. This consultant should also take part at least in the initial stages of implementation and should provide on-the-job training.

4. ALTERNATIVES FOR TECHNOLOGY TRANSFER TO FARMERS

When AZRI technologies are ready for transfer to dryland farmers there will be three alternative ways of performing this function. Alternative one: AZRI gives them to provincial extension agencies without taking any role in technology transfer. Alternative two: AZRI takes full responsibility to disseminate it's own technologies. Alternative three: AZRI cooperates in technology transfer with provincial extension agencies to ensure that its technologies will be transferred effectively.

Alternative one. In the PARC system, as a general rule, new technologies are transferred to farmers through provincial extension agencies because extension per se is a provincial responsibility in Pakistan. This mechanism, I am afraid, may not be very effective in the case of dryland technologies, because the provincial extension services focus almost exclusively on fast response areas such as irrigated agriculture. For example, the AZRI extension survey revealed that only 2 percent of dryland farmers had any personal contact with extension officers in Balochistan. Similarly, the Livestock Department is very active in providing animal health cover, but by tradition it works as a veterinary service with little attention to animal production and management extension. Also, a crucial area, range rehabilitation and management, has been never subject to extension work in Balochistan. I have no detailed information about other provinces, but at least in Balochistan it is clear that extension services are not ready to disseminate dryland agricultural technologies.

If we assume that, by the nature of dryland farming, AZRI technologies can provide incremental improvements rather than breakthroughs, I can not see strong incentives for the provincial extension services to shift their current emphasis and invest their limited sources into dryland technologies just because of their availability. Therefore, from a professional point of view alternative one is not the best option.

Alternative two. There are many research organizations which deal directly with technology transfer in the case of their own technologies. For example, Venkatesan[1] mentions that the Indian Council of Agricultural Research (ICAR) conducts extension programs such as National Demonstrations, Krishi Vigyan Kendras (farm science centers), Operational Research Projects and Lab to Land Programs. He claims "in the absence of professional extension this innovation [extension programs] was clearly necessary and beneficial."

In the light of the previous statement; Can it be "necessary and beneficial" for AZRI to undertake direct extension activities in the absence of interest in dryland agriculture by the provincial extension agencies.

Considering both the potential undesirable political consequences and an extensionists professional point of view, my response to this question is negative. Research institutions should not deal directly with extension because it is not a cost effective solution. Moreover, the extension function is always potentially subject to discrimination when undertaken jointly with any other development instrument, because it is, in general, less time-bound, less tangible and more difficult to achieve visible success than in other development activities. Thus, the second option, in my opinion is not feasible.

Alternative three. The screening out of the second alternative does not mean that AZRI should consider technology generation as its ultimate aim. In contrast, a strong institutional commitment to ensure effective transfer of its technologies is necessary. This commitment should lead AZRI to seek out suitable ways to support and collaborate with the provincial extension agencies such as cooperative extension projects, sponsorship for the dissemination of specific technologies, forming joint technology adaptation and transfer teams etc.

A detailed examination of such options is beyond the aim of this report. But, I must stress that, regardless to the type of cooperation, "institutional formal arrangements" are required between AZRI and the provincial extension departments to ensure effective and sustained transfer of dryland technologies to farmers.

WORKSHOPS

1. Video Production Techniques. Organized in cooperation with MART/IT Component. 10 June 1987. AZRI Auditorium.

2. Written Materials in Agricultural Extension. Organized in cooperation with BAEARP. 7 July 1987. AZRI Auditorium.

3. Planning for Effective Agricultural Communications. Organized in cooperation with MART/IT Component. 11 November 1987. AZRI Auditorium.

4. Seminar on Livestock Research and Extension. Organized in cooperation with the Baluchistan Livestock Department. 26-30 May 1989. Serena Hotel.

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CONCLUSIONS

In the period 1985-89, the MART/AZR project has gone a long way to obtaining the goals established for it in the MART PC1 document. The Arid Zone Research Institute is now a rapidly maturing scientific institution which is leading dryland agricultural research in Pakistan. The physical infrastructure of the institution is complete and has the necessary field equipment and laboratory facilities capable of supporting the ongoing research program outlined in AZRI's strategic research plan.

Human resources, though still inadequate in numbers at a post-doctoral senior level, are competent presently to undertake the current narrowly defined research program. With the continuing despatch and return of further longterm doctorate level trainees, the Institute's staff resources in the next five years will be more than capable of maintaining and leading AZRI's research efforts. The continuity of MART/AZR project activities, under a grant to ICARDA over the next three year period, will ensure that doctoral level staff returning from longterm training in the USA will receive a period of continuing research support as they assume the role of research leadership expected of them.

In the future, it is hoped that the seed planted by the Pakistan Agricultural Research Council at AZRI in 1980, and nurtured by the both PARC and the MART/AZR Project in the period 1985-89, will continue to allow a sustained and ever growing harvest of research results to assist the disadvantaged farming communities of the dryland agricultural areas of Pakistan.

MART/AZR PROJECT COMPLETE PUBLICATION LIST

a) Research Report Series

Buzdar, N., Nagy, J.G., Farid Sabir, G., Keatinge, J.D.H. and Mahmood, K. (1989). Rainfed agriculture in highland Balochistan: A farming systems perspective. MART/AZR Research Report 54. ICARDA, Quetta.

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