PN-ABS-557

TOWARD SOLUTIONS FOR STRESSED LANDS

BOSTID Project Summaries

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THE BOSTID-PARC RESEARCH PROGRAM

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بسم اللہ الرحمن الرحیم

USAID

AUGUST 1994

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PARC: PAKISTAN AGRICULTURAL RESEARCH COUNCIL
ISLAMABAD, PAKISTAN

بسم اللہ الرحمن الرحیم

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The following 25 BOSTID project summaries reflect the opinions of BOSTID program staff, project advisors, review coordinators, and external peer-reviewers. They are presented to give a candid assessment of the accomplishments and deficiencies of scientific work in the BOSTID-PARC Agricultural Research Grants Program, funded by the U.S. Agency for International Development, Islamabad. Much innovative and exciting research was performed, and many operational and scientific obstacles were overcome to reach this stage in the research in a little more than two years.

The project summaries are not for quotation or distribution. Despite difficulties and limitations in projects, significant progress was made by all research teams. Most projects will continue to collect research data to strengthen their initial findings from two years of studies and trials. The transfer of science to practice unfolds slowly, but I believe that research performed under this program will be repaid many times in the years ahead in the agriculture of the stressed lands of Pakistan and the world.

Judith Bale, Director
Pakistan Research Program

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BOSTID PROJECT SUMMARY
GRANT #1

Title: Transfer of *Bacillus thuringiensis* Genes to Chickpeas for Pod-Borer Resistance

Investigator(s): Dr. Fazle M. Khan, Dr. S. Riazuddin
Center for Advanced Molecular Biology, University of the Punjab, Lahore

Funds Awarded: $83,463 **Funds Spent:** $86,092*

Grant Period: 2/13/92-5/31/94

Project Objectives:

In Pakistan, chickpea is grown on about 1 million hectares and is the main source of protein for the rural population. The chickpea yield of 0.5 metric tons per hectare is the lowest in the world because of moisture, disease, and insect stress. Chickpea pod-borer (*Heliothis armigera*) is the major insect pest. The goal of this research was to develop genetic resistance to chickpea pod-borer through transgenic technology, leading ultimately to increased production of pulses and less reliance on the use of chemical pesticides. The study addressed five specific objectives:

1. To clone toxin crystal gene(s) of *Bacillus thuringiensis* (Bt) in *E. coli*; characterize, express, and test recombinants in *E. coli* for efficacy against *Heliothis*.
2. To determine the level of expression of pesticidal gene(s) and subclone active domain(s) of Bt in *E. coli*, and test again for activity against *Heliothis*.
3. To subclone resynthesized active domain(s) in plant binary vectors or tissue-specific expression vectors.
4. To develop transgenic chickpea lines through *Agrobacterium*-mediated transformation.
5. To study the stability of cloned genes and their expression in transgenic lines.

Project Status:

The above objectives have been addressed as well as could be anticipated by a two-year project. Several hundred strains of Bt were collected from local sources. Crude extracts were checked for toxicity against *Heliothis*, and 65 more purified isolates were prepared from the more toxic extracts. The toxicities of these were compared.

Plasmids were separated and a plasmid library established. One complete gene was restriction mapped and partially sequenced; it does not express in *E. coli*, possibly because it has a different promoter. Protein expression is now being tested in *B. subtilis* and its toxicity measured.

Transformation is being undertaken by two methods:

- Using *Agrobacterium* in Pakistan.
- Using the ballistic gun with collaborators in Seattle. A good regeneration system has been developed with mature embryos.

The expression of Bt in chickpeas will take 1 to 2 years.

Accomplishments:

This survey of natural isolates of *Bacillus thuringiensis* resulted in the isolation of at least three different Bt isolates that have now been cloned, and partly characterized and sequenced. Attempts to develop a transformation system for chickpea appear to have been partially successful, but it is not clear that a routine method suitable for plant breeders has been developed.

* This amount may be adjusted pending verification of the final expenditure report.

Publications:

One paper has been prepared: "Use of *Bacillus thuringiensis* Pesticidal Genes in Breeding Plant Resistance." Other papers will be submitted for publication.

Awards Received:

- Award for Achievement. This project deserves great credit for establishing an impressive molecular-biology laboratory, creating an excellent staff, and maintaining high research standards. The advances and leadership shown by the younger project investigators in molecular biology and transformation studies is especially commendable.
- Certificate of Merit for an excellent poster on the research undertaken in this research project. The poster was clear and artistic, highlighted the important points, flowed well, and included an original, relevant cartoon.

Collaboration:

This project was visited regularly by group advisors. In addition, the following grantee visits were made:

- Dr. Riazuddin spends 2 months each year at the University of Washington, Seattle, where he has a rich collaboration.
- Dr. Tayyab Husnain visited Dr. Milton Gordon, Department of Biochemistry, University of Washington, Seattle (August 6-November 30, 1993).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Beckman Instruments, Inc., rotor assemblies for centrifuge (3)
- New Brunswick Scientific Co. gyrotory shaker with accessories

Problems:

This project encountered few, if any, problems and has shown steady progress.

Application of Research:

The use of cloned Bt genes to protect chickpea against lepidopteran insect pests will be useful for Pakistani agriculture.

Future Support Needs:

With such a promising beginning, this program needs further support to allow the introduction of cloned genes in advanced lines of chickpea, as well as other crops, for use by plant breeders in Pakistan and elsewhere.

The project laboratory staff is capable and hardworking. Dr. Riazuddin has been successful in attracting funding from several international research agencies. Competition for these funds is intense, and it is to his credit that he has been successful.

BOSTID PROJECT SUMMARY
GRANT #2

Title: Conjunctive Use of Water from Varying Quality Sources on Salt-Affected Land

Investigator(s): Dr. Tahir Hussain
Department of Soil Science, University of Agriculture, Faisalabad

Funds Awarded: $76,769 **Funds Spent:** $75,587*

Grant Period: 4/9/92-5/31/94

Project Objectives:

The primary constraint on agricultural production in Pakistan is the limited supply of irrigation water. The purpose of this project was to develop an appropriate and efficient technology for utilizing poor-quality water to increase the area that can be irrigated for sustainable crop production. The specific objectives of this study were as follows:

1. To determine how to make effective use of "cyclic" and "blended" combinations of canal and tube-well irrigation water for rice-wheat and cotton-wheat crop rotations.
2. To identify the effects of drainage water reuse strategies on the physical and chemical characteristics of soil used in rice-wheat and sugarcane-wheat rotations, over a period of 2 years or more.
3. To determine the effects of biological and chemical amendments on physical and chemical characteristics of soil irrigated with sodic tube-well water, and associated economics, over a period of 2 or more years.
4. To determine whether sodic water from tube-well and/or surface drainage water can supplement canal water under various crop rotations.
5. To determine how to establish sustainable crop production using poor-quality water and maintaining the physical and chemical characteristics of the soil.

Project Status:

Work on all objectives of the project is well under way, but more crop rotations must be monitored to determine the sustainability of using brackish well water cyclically with canal water for irrigation.

Accomplishments:

The researchers began experiments related to conjunctive use of saline-sodic groundwater and nonsaline canal water for alternative crop rotations, with and without the use of amendments to counteract the damaging effects of sodium on soil structure and water infiltration rates.

The team made excellent progress on the study within the time frame. Based on two growing seasons, research results indicate that brackish water can be used successfully for crop production under proper water management strategies. Blending of sweet and brackish water has a negative impact on crop productivity; however, first using sweet water to establish rice and wheat, then cycling to brackish water, can produce yields comparable to those obtained using good-quality irrigation throughout the growing cycle, while also minimizing the development of sodic, saline soils. Significant data was also generated on the use of various amendments (sulfuric acid, gypsum, manure, pressmud, etc.) to neutralize brackish drainage and well water. Innovative methods of recruiting field workers (free hot dinners) and ensuring attendance at demonstrations (free food and camping) have already created awareness of this work among local farming communities.

* This amount may be adjusted pending verification of the final expenditure report.

BOSTID funding was used to develop a field research station, including installation of a shallow groundwater well and water-flow measurement structures to measure the volume of water delivered from the well, as well as from the canal that serves the field. The plot layout included a water-delivery system of individual plots. The development of these research facilities is an important accomplishment that will be valuable for future research as well as for this project.

Publications:

The following paper has been prepared for publication: "Conjunctive Use of Water from Good and Poor-Quality Sources to Extend Irrigated Area and Reduce Disposal Problem in Salt-Affected Soils."

The following dissertations have also been generated by this research:

- Akhtar, M.A. 1994. *Strategies for the Utilization of Brackish Groundwater for Crop Production*. Ph.D. Thesis (in preparation). Department of Soil Science, University of Agriculture, Faisalabad.
- Mahmood, A. 1994. *Cyclic vs. Blended Use of Canal and Brackish (Tube Well) Waters for Crop Production*. M.Sc. Thesis. Department of Soil Science, University of Agriculture, Faisalabad.
- Qaiser, M.A. 1994. *Effect of Cyclic Use of Brackish Water on the Yield and Quality of Sugarcane*. M.Sc. Thesis. Department of Soil Science, University of Agriculture, Faisalabad.
- Hussain, N. 1994. *Amelioration of Brackish Water through Organic and Chemical Amendments*. Ph.D. Thesis (in preparation). Department of Soil Science, University of Agriculture, Faisalabad.

Collaboration:

This project was visited regularly by group advisors. In addition, there was a consultant visit by Dr. James Rhoades, Director, U.S. Salinity Laboratory, Riverside, California, to Faisalabad (February 8-17, 1994). There was also a grantee visit by Dr. Tahir Hussain to Water Management Laboratory (Dr. James Ayars), Fresno, California; Department of Soil and Environmental Sciences (Dr. James Oster), University of California, Riverside; the U.S. Salinity Laboratory (Dr. James Rhoades), Riverside; and the University of California (Dr. Steven Gratten), Davis (August 17-September 2, 1993).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Perkin-Elmer International atomic absorption spectrometer (with accessories and software)
- AST Research, Inc. computer with software and mouse
- Lexmark laser printer

Problems:

The project has not yet "packaged" a set of practices that addresses the use of poor-quality irrigation water in an integrated manner in terms of production systems that include soil and water, as well as crop management practices that ensure sustainability and profitability. Unless offset by appropriate management practices, use of saline, sodic irrigation waters can lead to devastating problems of salinity, sodicity, toxicity, and nutritional deficiency.

Continued support will be required to maintain the project facilities, cover the analysis of soil and crop samples, and support the staff running the experiments. There is good potential here.

Application of Research:

This research is very relevant in Pakistan and several other countries. There are very significant benefits to be derived if an affordable, sustainable strategy and set of management practices can be established in the areas addressed by this project. Adoption of these new techniques on appropriate soils could improve water-use efficiency and cropping intensity, while allowing an increase in the amount of land under irrigation. The research team seems dedicated to demonstrating the practicality of their results.

The team's preliminary results are consistent with research conducted in the United States and Israel: saline and saline-sodic irrigation waters can be used to grow crops that are at least moderately tolerant to salinity.

Research on chemical amendments, particularly organic amendments such as manure and crop residues, fills a gap in the current knowledge base.

Future Support Needs:

Canals to deliver drainage water to fields have recently been completed, which will allow a field-scale pilot study of water management strategies. The sustainability of conjunctive use of poor- and good-quality water at the field site will take at least 5 years to establish. This should be done after close review of similar experiences in the United States and Israel: irrigating with poor-quality water is a deadly serious business because of the harm that can be done to the agroecological system.

It seems likely the researchers will extend their information to farmers through field days, training of extension workers, and development of written materials for farmers and extension workers.

In addition to local extension, the researchers have established a strong relationship with colleagues at the U.S. Salinity Laboratory, who are participating in project planning and data analysis. The research team intends to design and demonstrate flexible, integrated management packages for utilizing saline/sodic groundwater to enhance the limited supply of fresh water. A crucial need is to expand the coverage of various soil types and cycling regimes.

BOSTID PROJECT SUMMARY
GRANT #3

Title: Water Harvesting to Enhance Crop Production in Highland Balochistan

Investigator(s): Dr. Zahid Ali Qureshi
Arid Zone Research Institute, Quetta

Funds Awarded: $69,460 **Funds Spent:** $50,167*

Grant Period: 2/18/92-5/31/94

Project Objectives:

The harsh climate of the Balochistan Province subjects crops to considerable stress, and therefore yields are usually very low. Harvesting water from the catchment basin has improved crop yields and reduced the risk of crop failure. The general objective of this project was to establish sustainable water-harvesting techniques for the gently sloping, valley-bottom lands of highland Balochistan, improve crop yields, and increase the area in production. The specific objectives for the study were as follows:

1. To determine the optimal area of water-harvesting fields, and to quantify water-use efficiencies obtained from improved water-harvesting treatments and better agronomic practices.
2. To measure the reduction in the risk of crop failure by the application of water-harvesting practices.
3. To evaluate drought-resistant species suitable for food and fodder.
4. To select the best water-harvesting techniques for the kushkhaba areas of highland Balochistan--techniques appropriate for the local socio-economic and geohydrologic conditions.

Project Status:

The project has addressed the objectives of the grant.

Accomplishments:

The project demonstrated technology that is practical, effective, and can be applied by farmers with limited capital. It has shown that harvesting of water in catchment basins can increase crop production and yield in this arid region. Preliminary data from the project suggest an optimal assignment of field-catchment area to production area. A survey of farmers indicates significant interest on their part if the technique is shown to be effective and inexpensive.

Publications:

The following paper has been prepared for publication: "Micro-catchment Water Harvesting to Increase Soil Moisture and Crop Production in Balochistan."

Collaboration:

This project was visited regularly by group advisors. In addition, there were consultant visits:

- Dr. B. A. Stewart, Dryland Agriculture Institute, Canyon, Texas, to AZRI, Quetta (February 21-26, 1993)
- Dr. John Stednick, Earth Resources Department, Colorado State University, Fort Collins, to AZRI, Quetta (January 2-15, 1994)

There was also a grantee visit by Dr. Zahid Ali Qureshi to Dryland Agriculture Institute (Dr. B.A. Stewart), West Texas A&M University, Canyon, and to the Biological and Irrigation Engineering Department (Dr. Lyman S. Willardson), Utah State University, Logan (January 25-February 2, 1994).

* This amount may be adjusted pending verification of the final expenditure report.

The researchers also collaborated in the collection of weather data (BOSTID-PARC Project #4) and in the measurements of runoffs (BOSTID-PARC Project #11).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Sentry depth moisture gauge with accessories
- Ohaus Scale Corporation balance

Problems:

This project had problems caused by changes in leadership of both the project and the Arid Zone Research Institute. The current research team is commended for their efforts to plan and publish research results from the work that was accomplished.

Erratic, late, and low rainfall also affected the experiments.

Two additional problems arose. At first, the test plots were not managed with the usual farm management practices, so it was difficult to apply results from the project to other field situations; strategies for transferring the technology to farmers were also unclear. There was an added problem with putting the collected data into usable form. Both problems were corrected.

Site visitors stressed to the principal investigator the importance of collaborating with other researchers and of acknowledging the contributions of other research to knowledge in his research area. This is particularly important in papers submitted for publication.

Application of Research:

Harvesting water from microcatchments shows good potential for increasing grain production and decreasing production costs in Balochistan. Farm-based water-harvesting research has now begun at several research sites. These trials include a component to measure the effects of traditional management techniques on yield. As with all projects that involve field trials, data must be collected from several seasons to yield confidence in the conclusions and their application.

Future Support Needs:

Based on the results obtained, the next steps would include assessment of water-delivery efficiencies, further determination of optimum ratios of land for catchment and for crop area, weir designs to control the excess flow of water to croplands, establishment of catchment basins over a wider area, demarcation of appropriate areas for use of the technology, and greater involvement of farmers in the field trials.

BOSTID PROJECT SUMMARY
GRANT #4

Title: Improved Management of Indigenous Breeds of Sheep in Highland Balochistan

Investigator(s): Dr. Shahid Rafique
Arid Zone Research Institute, Quetta

Funds Awarded: $75,500 **Funds Spent:** $74,484*

Grant Period: 2/18/92-5/31/94

Project Objectives:

Heavily degraded rangelands cover over 90% of highland Balochistan, and this area is excessively grazed by 18 million sheep and goats. The overall of this study was to measure the productivity of degraded land grazed by local breeds of sheep, and to develop management strategies for improving the fertility of ewes, the growth of their lambs, and the feeding of pregnant and lactating ewes, using farm flocks. Specific objectives of the study were as follows:

1. To determine the relationship between fertility and the live weight and body condition score of Balochi and Harnai ewes grazing degraded ranges.
2. To measure the effect of breeding in August, October, and December on the fertility of these Balochi and Harnai ewes.
3. To measure the growth rate and mortality of lambs from these ewes when their feed is supplemented during late pregnancy and early lactation.
4. To measure the growth potential of male Balochi and Harnai lambs under intensive fattening conditions.
5. To measure the economic benefits and costs associated with sheep production using different management strategies.

Project Status:

The objectives of the project have largely been completed: objectives 1, 3, and 4 are complete; 5 will be completed this year; and 2 was de-emphasized to allow a stronger focus on 1, as recommended by Dr. David Thomas.

Accomplishments:

Interesting and useful results were achieved on minimum protein supplementation requirements for ewes and lambs of indigenous breeds. The results of this research have potential for increasing meat production once successful range management is realized.

Publications:

The following papers have been prepared for publication:

- "Effect of Feeding Low and High Protein Rations on the Performance of Balochi Lambs under Intensive Feedlot Conditions"
- "Ewe and Lamb Performance as Influenced by Supplemental Feeding During Breeding, Late Gestation and Early Lactation in Highland Balochistan"
- "Monitoring of On-Farm Performance of Balochi and Harnai Sheep and Goats Raised under Traditional Management in Highland Balochistan"
- "Assessing the Fattening Potential, under Intensive Feedlot Conditions, of Balochi and Harnai Lambs Fed Two Energy Levels in Highland Balochistan"

* This amount may be adjusted pending verification of the final expenditure report.

Collaboration:

This project was visited regularly by group advisors. In addition, there was a consultant visit by Dr. David Thomas, Department of Meat and Animal Science, University of Wisconsin, Madison, to AZRI, Quetta (November 14-24, 1992).

There were also two grantee visits:

- Dr. Shahid Rafique to the U.S. Sheep Experiment Station (Dr. James A. Fitzgerald), Dubois, Idaho (August 8-27, 1993)
- Dr. Inam-Ul Haq to Texas A&M University, San Angelo (Dr. Millard Calhoun, ARS/USDA); to the Department of Animal Sciences (Drs. John Glenn, Dan Brown, and Eric Bradford), University of California, Davis; and to the Hopland Research and Extension Center, University of California, Hopland, California (March 12-26, 1994)

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Labconco Corporation crude fiber apparatus
- Isotemp oven with shelf
- Fisher Scientific balance

Problems:

There were problems in the design of the project. Because of the logistics and the small number of animals available for each trial, variability within the breeds could not be properly accounted for within the time limitations. Also, the initial allocation of animals to treatment sets by body weight confounded later analyses of gain and efficiency.

Application of Research:

This work addresses an important topic for Balochistan. As confirmed by these experiments, strategic supplementation of livestock can dramatically increase growth and reproduction rates in these harsh environments. These results are being applied by selected farmers using local production practices, and monitored by the researchers.

Once issues of overstocking and nutritional management of range animals have been successfully addressed, this research can have a significant impact in improving sheep production.

Future Support Needs:

More trials with more animals would enhance the usefulness of these results. Most important is analysis of the costs and returns of intensive and supplemental feeding of ewes and lambs.

BOSTID PROJECT SUMMARY
GRANT #5

Title: Development of an Integrated Pest Management System for Cotton in Sindh

Investigator(s): Dr. Ahmed Ali Baloch
Cotton Research Institute, Sakrand

Funds Awarded: $55,470 **Funds Spent:** $36,901*

Grant Period: 3/4/92-5/31/94

Project Objectives:

In Pakistan, cotton is an important cash crop, with total production ranking fifth in the world. High-yielding varieties with the potential for 1400-2000 kilograms per acre have been developed. However, 80% of the growers produce only 600-800 kilograms per acre, largely because of losses to insect pests. The overall objective of this project was to develop an integrated pest management (IPM) system focused on the use of bio-control agents.

Development of an IPM system for cotton requires detailed information on the characteristics of important pests, and the effectiveness of chemical and biological control agents. Currently, more than 60 products are registered for use against cotton pests. This project was aimed at developing a pest management system that would be economically and environmentally sound, with focus on the sucking complex of insects, predominantly jassids, thrips, and whitefly.

Development of an IPM system must rely heavily on existing data for the pest complex, especially for a system not driven by pesticides. The database must include detailed information on the biology and ecology of each pest and its natural enemies within and outside the cropping system. Without this information, a system is likely to fail or become highly dependent on pesticides.

Specific objectives of this study were as follows:

1. To complete reports on the biology and ecology of the major insect pests attacking cotton in Sindh, and initiate studies in areas where data is needed on these pests and their natural enemies.
2. To identify alternate host plants of insect pests and their natural enemies, and study the pest biology on these plants.
3. To evaluate new formulations of *Bacillus thuringiensis* and other insecticides for controlling insect pests of cotton and effects on natural enemies.
4. To write a general article on the biology of the whitefly, *Bamesia tabaci*, for publication in an international journal.

Project Status:

The objectives given have been largely completed for the seasons available, but data over more seasons are needed to consolidate and verify the initial results.

Accomplishments:

The researchers have recorded an enormous amount of data on the population dynamics of cotton pests in Sindh, the occurrence of their natural predatory and parasitic enemies, and the effects of cotton-pest pesticides on these enemies (which reduce pesticide effectiveness). Also recorded were the influence of using pest-resistant cotton varieties and of various cultural controls, such as changes in planting dates and irrigation intervals, as well as eradication of alternate host plants. These observations and the analyses performed to date have served as a first step in developing an IPM strategy for this crop.

* This amount may be adjusted pending verification of the final expenditure report.

Publications:

The following papers have been prepared for publication:

- "Integrated Pest Management in Cotton in Sindh, Pakistan: I. Natural Enemies of Insect Pests"
- "Development of Integrated Pest Management in Cotton in Sindh, Pakistan: II. Control by Management"

Collaboration:

This project was visited regularly by group advisors. In addition, a grantee visit was made by Drs. Ahmed Ali Baloch and Ali Mohammed Kalroo to (1) the Methods Development Laboratory of the Animal and Plant Health Inspection Service (Drs. Bob Staten and Fred Stewart) and the Insect Biological Control Research Laboratory, Western Cotton Research Center (Drs. Thomas J. Hennebury and Alan Cohen), U.S. Department of Agriculture in Phoenix, Arizona; (2) the Brawley USDA Irrigated Desert Research Station in El Centro, California; and (3) the APHIS cotton insects research and rearing teams in Weslaco and Mission, Texas (Drs. Edgar King and Ray Curruthers) (March 11-28, 1994).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- AST Research, Inc., computer with software and mouse
- Lexmark laser printer with warranty

Problems:

The researchers attempted to do too much; research such as this requires greater focus. Good sampling techniques were not developed, so most of the data are qualitative. In addition, a cause-effect relationship was not established to show that the parasites/predators were causing mortality among the cotton pests. These problems with experimental design and statistical analysis were partially resolved.

Inroads on pesticide reduction need better quantification of the natural enemy complex outside of the cotton system--focusing not on other crops, but on refugia, such as wild-plant hosts.

This research was part of a broader program at the Cotton Research Institute in Sakrand. As a result, much of the data reported was not related to the project objectives, but to institutional responsibilities. Thus, much of the information was presented as station reports rather than research statements subject to peer review.

Application of Research:

The researchers were able to show that Bt materials are effective against cotton boll-worm. This is particularly useful because Bt can subdue a major pest without destroying the natural enemy complex. Using the data available, initial recommendations have been made that could reduce pesticide use by one-third without additional crop losses.

Future Support Needs:

This type of broad-based field research requires several growing seasons for the data to have credibility. The data collected thus far have laid the groundwork for more focused quantitative and practical research that could eventually have a major impact on pesticide use as well as cotton yield and profitability in Sindh. It is possible that these methodologies might also prove useful in other regions initiating IPM research studies.

BOSTID PROJECT SUMMARY
GRANT #6

Title: Tolerance of Wheat to Hypoxia and Salinity

Investigator(s): Dr. Riaz H. Qureshi
Saline Agriculture Research Cell, Department of Soil Science, University of Agriculture, Faisalabad

Funds Awarded: $81,516 **Funds Spent:** $70,026*

Grant Period: 4/9/92-5/31/94

Project Objectives:

On the basis of preliminary, collaborative studies between the Saline Agriculture Research Cell at the University of Agriculture, Faisalabad (UAF) and the Centre for Arid Zone Studies (CAZS), University of Wales, Bangor, this project undertook detailed studies on the anatomical, physiological, and biochemical parameters involved in the tolerance of wheat cultivars to hypoxic (low-oxygen) salinity. The general objective was to improve the productivity of wheat under hypoxic, saline field conditions. The specific objectives were as follows:

1. To determine the effects of anoxic or hypoxic conditions on salt tolerance for wheat growth/productivity.
2. To develop a quick procedure for screening wheat cultivars for tolerance against hypoxic salinity, and to determine the anatomical, morphological, and physiological changes in the roots as they adapt.
3. To determine the differences among wheat varieties in tolerance to hypoxic salinity, and whether this tolerance is related to (1) the amount and/or rate of parenchyma production, and (2) increased uptake of Na+ and Cl-.

Project Status:

The objectives of this project have generally been addressed by the experiments undertaken, and the best wheat varieties have been selected. SARC 3 produced yields similar to those of PB.85 under conditions of salinity and waterlogging, but has not yet been tested for resistance to rust.

Accomplishments:

The researchers used a sound experimental design that yielded valid data, while documenting the extent of the salinity/waterlogging problem in some areas of Pakistan.

The research facilities and experimental design represent accomplishments in themselves. Both laboratories and field plots were maintained in excellent condition throughout the study. In particular, the lysimeter studies showed dramatic and definitive results and will prove an excellent experimental and teaching tool in the future. The research methodologies shed light upon how findings on salinity and hypoxia may support the development and selection of criteria for cultivated crops, using wheat as a model. In addition, the team--which had excellent interaction--showed a flexibility to add tasks and alter directions as data and observations dictated.

Publications:

The following papers have been prepared for publication:

- "Effect of Salinity and Hypoxia on Wheat Growth and Ionic Relations: A Greenhouse Study"
- "Comparative Physiology and Root Anatomy of Two Wheat Varieties Exhibiting Differential Growth Response to Salinity and Hypoxia"

* This amount may be adjusted pending verification of the final expenditure report.

Collaboration:

This project was visited regularly by group advisors. In addition, there was a consultant visit by Dr. Michael Shannon, U.S. Salinity Laboratory, Riverside, California (April 13-24, 1993). A grantee visit was made by Dr. Shafqat Nawaz to the Department of Agronomy and Range Science (Dr. D. William Rains), University of California, Davis (October 24-November 5, 1993). Dr. Shafqat Nawaz also attended the American Society of Agronomy meeting, Cincinnati, Ohio (November 6-12, 1993).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Energy Beam Sciences rotary microtome
- Energy Beam Sciences plastic sectioning kit for rotary microtome
- Energy Beam Sciences knife holder for rotary microtome

Problems:

This project--like so much research on salinity and despite the wide array of research available--has made limited progress at accomplishing its challenging overall objective of improving the productivity of wheat under hypoxic, saline field conditions. In fact, one of the project's designated cultivars (K-65) was proposed as a salt-tolerant germplasm in the 1970s, and another (KRL 1-4) was developed by the team's Welsh collaborator.

Application of Research:

Although the research was directed at an important agricultural problem, this project focused on basic research, rather than on the application of established techniques to selecting and developing tolerant cultivars. However, the research team is now positioned to make qualitative contributions to cultivar testing and release in Pakistan, using the analytical techniques developed during this study.

Future Support Needs:

Application of the anatomical, physiological, and biochemical parameters developed by this research is needed. The basic findings should be applied to actual circumstances and to development of genotypes that exhibit tolerance. There is now a well-established base for proceeding with research using the leading higher-yielding, better-adapted wheat cultivars to address Pakistan's production demand and needs. This is especially true for cultivar Lu26-S, with which the principal investigator has had considerable experience, as well as other cultivars mentioned above. Another important focus for future work is the conventional genetic variations prevalent in the primitive cultivars of Pakistan and their improved derivatives.

BOSTID PROJECT SUMMARY
GRANT #7

Title: Development of Salt-Tolerant Varieties of Wheat

Investigator(s): Dr. Shafqat Farooq
Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad

Funds Awarded: $56,700 **Funds Spent:** $58,284*

Grant Period: 2/23/92-5/31/94

Project Objectives:

Wheat is the major staple in Pakistan, where annual production is 12-15 million tons. The demand for wheat has led to major efforts to increase both the crop's productivity and land under production. Increasing the land under wheat production will require expansion into salt-affected areas that comprise 41% of Pakistan's cultivable land. To this end, salt-tolerant varieties of wheat must be developed and shown to be productive.

Since the genetic base for salt tolerance in internationally available wheat varieties is narrow, this project involved using perennial wild wheat grasses to introduce salt tolerance. This approach was complicated by the polygenic nature of salt tolerance, but the study was based on positive preliminary results.

The overall objective of the study was to test promising wheat accessions developed thus far on saline land, and to hybridize other salt-tolerant accessions of *Aegilops cylindrica* with commercially cultivated wheat varieties. The specific objectives of the study were as follows:

1. To cultivate saline lands (electrical conductivity 15-20 DS/M) with wheat germplasm already generated through crosses of wheat with salt-tolerant *Ae. cylindrica*.
2. To increase the salt tolerance of hexaploid wheat varieties through wide hybridization using wild salt-tolerant species.
3. To evolve improved salt-tolerant germplasm through wide hybridization of commercially cultivated hexaploid wheat varieties with salt-tolerant accessions of *Ae. cylindrica*.

Project Status:

All three of the above objectives have been pursued vigorously and have involved both pot and field studies. Several wheat varieties have been developed through wide hybridization. Testing of these and additional varieties will continue for several years.

Accomplishments:

This project was a valuable expansion of earlier studies. An active research team was assembled and good facilities developed. Salinity stress in wheat is an overwhelming physiological problem, and even partial successes are a worthwhile investment.

The technique of wide hybridization to obtain germplasm appears effective, and progress was made on developing material with good potential. The field responses of some germplasm indicate encouraging progress in combining salt tolerance from *Aegilops* with a leading variety of wheat. One concern is that wheat varieties with rust resistance be used in the breeding for tolerance to saline conditions.

The researchers also attempted several novel approaches to utilization of random amplified polymorphic DNA (RAPD) genetic data, a new research tool whose use and application is expanding rapidly. Although the peer reviewers noted that the results obtained so far require further replication and validation through more conservative techniques, the use of the technique shows good initiative.

* This amount may be adjusted pending verification of the final expenditure report.

Publications:

The following papers have been prepared for publication:

- "Production and Evaluation of Salt-Tolerant Wheat Germplasm Derived Through Crosses Between Wheat (*Triticum aestivum* L.) and *Aegilops cylindrica*. I. Production of Salt-Tolerant Wheat Germplasm"
- "Production of Salt-Tolerant Wheat Germplasm Through Crossing Cultivated Wheat with *Aegilops cylindrica*. II. Field Evaluation of Salt-Tolerant Germplasm"
- "Identification of Different Wheat Genotypes Through Polymorphism Based on Random Amplified Polymorphic DNA (RAPD)"

Award Received:

Dr. Shafqat and her team received an Award for Excellence in Research. Dr. Shafqat has created and led a well-coordinated research team that has produced high-quality, applicable research and excellent papers.

Collaboration:

This project was visited regularly by group advisors. In addition, there was a consultant visit by Dr. Michael Shannon, U.S. Salinity Laboratory, Riverside, California (April 13-24, 1993). There was also a grantee visit by Mr. Tariq Mahmud Shah to the Department of Agronomy (Dr. Lane Rayburn), University of Illinois, Urbana (July 10-September 12, 1993). In addition, Dr. Shafqat Farooq attended the 17th International Congress of Genetics, Birmingham, England (August 13-29, 1993).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Stratagene still video system
- Hotpack growth chamber
- Jouan, Inc. refrigerated centrifuge
- Fisher Scientific analytical balance with interface
- VWR Scientific refrigerated circulating bath
- Stratagene transilluminator for still video system

Problems:

Heterogenous soils in the field sites led to high variability in the data; this can be overcome with time or use of different sites.

External reviewers are unanimous that conclusions should be based on the presence or absence of banding, not on banding intensity, in DNA fingerprints. Variations in banding intensity are common, difficult to control, and not acceptable as the basis for this kind of analysis. The researchers may not be able to differentiate some specimens solely by the presence or absence of banding, but analysis must still use this conservative approach to be accepted in peer review.

There were initial difficulties with new equipment, but these were resolved.

Application of Research:

As field trials of this research are completed, there is promise that a much broader range of salt-tolerant wheat germplasm will be available in Pakistan. If any of this material is cultivable in areas now used for less desirable crops, it could have an important impact on future production.

Future Support Needs:

Promising crosses have been made that may fill the salt-tolerance gap created by LU-26's increased susceptibility to rust. Field trials and continued breeding--especially with leading cultivars--are required to bring this promising start to its logical conclusion. It may even be possible to extend the area of land in Pakistan that is amenable to wheat cultivation, and the new varieties might prove valuable in other parts of the world as well.

New methods to distinguish wheat lines from one another are needed, and RAPD may well be able to serve this purpose. If so, a powerful technique for qualifying newly created transgeneric crosses may be available; this in turn would greatly increase the number and speed of evaluations that can be made.

BOSTID PROJECT SUMMARY
GRANT #8

Title: Development of Transgenic Brassica Expressing Bt Toxin Gene (formerly titled "Construction of a Linkage Map(s) and Identification of Disease Resistance Gene(s) in Brassica")

Investigator(s): Dr. S. Riazuddin
Center for Advanced Molecular Biology, University of the Punjab, Lahore

Funds Awarded: $81,160 **Funds Spent:** $82,483*

Grant Period: 2/13/92-5/31/94

Project Objectives:

Production of edible oil in Pakistan has remained stationary, while domestic consumption has increased to the point that imports of edible oil consume 75% of the foreign exchange allocated to food. Domestic oil production is from cotton seed (71%) and rapeseed (21%). Since cotton is grown primarily for export of the fiber, there is a strong reluctance to use genetic manipulation to improve oil production and possibly reduce the fiber content at the same time. Improving production of oil from rapeseed is more feasible. Constraints that limit the productivity of rapeseed include (1) lack of high-yielding varieties, (2) inadequate adoption of improved practices, and (3) lack of quality seeds. However, the key constraint is damage by insects, the most important being the aphid.

Brevicoryne brassicae F. is a common species of aphid that is responsible for most of the damage to rapeseed. While breeders have improved yields and reduced the content of erucic acid and glucosinolates in rapeseed, insect resistance has not been achieved. The specific objectives of this study were as follows:

1. To transform Brassica with marker genes.
2. To investigate the stability and expression of the foreign genes in Brassica plants.
3. To establish an aphid insectory and develop bioassays.
4. To test previously collected Bt isolates against laboratory-reared aphids, in order to discover pesticidal bacterial genes.
5. To investigate newly discovered pesticidal genes for DNA homologies, if any, with previously characterized cry genes.
6. To develop Bt gene constructs to express in Brassica plants.

Project Status:

This project ran into major difficulties in the first year when the promised homogeneous lines of *Brassica* were not available to the project. After several attempts to overcome this problem, the research objectives were revised to those above, and acceptable progress was made on the new objectives.

Accomplishments:

This project has shown modest progress towards effecting a transformation system of *Brassica napus*. The project has reported, but not documented, the development of a biotoxicity assay to test the effectiveness of isolates of *Bacillus thuringiensis* against the Brassica aphid, *Brevicoryne brassicae*. If, in fact, unique isolates have been found that have toxicity against aphids, this work and all supporting data needs to be published promptly.

* This amount may be adjusted pending verification of the final expenditure report.

Publications:

The following paper has been prepared for publication: "Integrated Pest Management in Brassica."

Collaboration:

This project was visited regularly by group advisors. In addition, there was a consultant visits by Dr. Vic Knauf, Calgene, Davis, California, to Lahore (October 21-November 2, 1992).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- The Baker Company vertical laminar flow hood with Class II safety cabinet
- Hoefer Scientific Instruments fluorometer with accessories
- Bio-Rad Laboratories Trans-Blot semi-dry cell system with power supply
- Bio-Rad Laboratories power supplies for Bio-Rad equipment (2)

Problems:

This project suffered a serious set-back soon after it began: crucial germplasm (an homogenous line of *Brassica*) was unavailable for experimental purposes. This necessitated a significant restructuring of research methodologies and goals. There was also a change of leadership.

Application of Research:

Effective control of aphids through the introduction of Bt genes toxic to this class of insects would have important implications in Pakistan and beyond. Damage due to aphids is important in world agriculture.

Future Support Needs:

The needs of this project must be carefully gauged. If the supporting data for the reported accomplishments are adequate, the project will need as much support as PARC can muster since the accomplishments claimed are of considerable practical significance. In the absence of supporting data, it is difficult to judge how reliable these claims are. The data need to be reviewed by an entomologist experienced in controlling aphids. If Bt toxins are effective, they will need to be used wisely. There is much evidence that using Bt in transgenic plants to control lepidopteran and coleopteran pests may fail because of the development of resistance to Bt toxins in these insects.

BOSTID PROJECT SUMMARY
GRANT #9

Title: Control of Hydropericardium Syndrome (HPS) in Poultry

Investigator(s): Dr. Ashiq H. Cheema, Dr. Khalid Naeem (Epidemiologist)
National Agricultural Research Centre (NARC), Islamabad

Funds Awarded: $72,350 **Funds Spent:** $68,415*

Grant Period: 3/30/92-5/31/94

Project Objectives:

Commercial poultry farming was established in Pakistan in 1964, and over the last 30 years, production has increased to 85 million birds annually. There is pressure to further increase poultry production to meet the country's need for animal protein. Inadequate nutrition and poultry diseases are major limitations to increased productivity.

Beginning in 1987, a new disease, hydropericardium syndrome (HPS), destroyed two-thirds of the broilers produced in Pakistan. Researchers at NARC consider avian adenovirus to be the cause of the disease, but believe that an associate virus is required to produce the disease.

The overall objective of this project was to clarify the etiology of the disease and produce an effective vaccine, thus improving the productivity of poultry farming in Pakistan. The specific objectives of the study were as follows:

1. To isolate, identify, and characterize the etiologic agent of hydropericardium syndrome.
2. To record the chronological development of the disease symptoms.
3. To determine the lateral and vertical spread of HPS.
4. To develop a vaccine for HPS, and identify the immunogenic component(s) of HPS agent(s).
5. To describe use of the vaccine for farmers, including dosage and method of application.

Project Status:

This project involved three collaborators working on different aspects of the disease: pathology, virology, and epidemiology. On his U.S. research visit, Dr. Cheema undertook routine histopathology and immunoperoxidase studies. For these studies, he needed monoclonal antibodies, but these were not yet available. The experiments were therefore done using polyclonals, but the results obtained were nonspecific. The visit provided experience with tissue culture. Now that the needed monoclonals are available, Dr. Cheema is attempting to set up the immunoperoxidase studies in Islamabad.

During his research visit at Iowa State University, Dr. Naeem became convinced that HPS is caused by adenovirus alone. He produced the disease in chicks in the absence of any other virus.

Dr. Saeed Akhtar compiled and analyzed responses to the epidemiological survey of HPS.

Accomplishments:

Reviewers felt that this research addressed an important topic. Their conclusions on the effect of HPS on antibody formation to Newcastle Disease Virus (NDV), the sequential spread of the virus to various tissues, and reproduction of HPS using various tissues are justified by the data presented.

The researchers made the important observation that an adenovirus(es) that causes or is associated with HPS in broiler chickens also suppresses the birds' immune functions. Their epidemiological studies provide useful information for further investigation of field outbreaks of HPS.

As a result of this research, there is now a clearer explanation of the etiology of HPS in poultry. A better vaccine appears to have resulted from this work, and there is new evidence on how the agents responsible for HPS spread in infected flocks.

* This amount may be adjusted pending verification of the final expenditure report.

Publications:

The following papers have been prepared for publication:

- "Immunosuppressive Potential and Pathogenicity of an Avian Adenovirus Isolate Involved in Hydropericardium Syndrome in Broilers"
- "A Study on Lateral Spread of Aetiologic \gent(s) of Hydropericardium Syndrome in Broiler Chickens"

Award Received:

The project received the Award for the Best Poster at the Final Conference of the PARC-BOSTID Research Program. The poster was well written, artistic, highlighted key points, and conveyed the information effectively.

Collaboration:

This project was visited regularly by group advisors. There were two grantee visits:

- Dr. Khalid Naeem to the Diagnostic Virology Laboratory of Dr. B. Panigrahy at the National Veterinary Services Laboratories in Ames, Iowa (July 24-August 20, 1993).
- Dr. Ashiq Cheema to the Wiley Laboratory (Dr. Barrett S. Cowen), Department of Veterinary Science, The Pennsylvania State University, State College (August 29-September 26, 1993).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Miles Inc. cryostat with microtome
- Jouan, Inc. refrigerated centrifuge
- Hoefer Scientific Instruments power supply for electrophoresis unit
- Shelton Scientific, Inc. microcentrifuge with rotor
- Fotodyne Incorporated photophoresis documentation station

Problems:

The laboratory conditions in Islamabad are not well suited to sophisticated biochemistry and molecular biology. The lack of various kinds of equipment and techniques created considerable obstacles. Had Dr. Naeem been able to spend a longer time in the United States, some remaining questions on the nature of the agent might have been resolved.

The etiology of HPS disease--although clarified--requires more study. Information on HPS should be more closely related to knowledge of other adenoviral infections, particularly inclusion body hepatitis. This virus is similar or identical to the disease that causes or is associated with chickens in Pakistan. More robust data are necessary to distinguish HPS (a secondary lesion) from inclusion body hepatitis, which is characterized by intranuclear inclusions in liver cells, possibly caused by adenovirus(es).

Application of Research:

HPS is an important disease in Pakistan, and this work is a significant step towards its control. Continued research could lead to further significant discoveries, such as confirming the cause(s) of HPS and means for its practical control through development of a cell-free vaccine.

Future Support Needs:

It is necessary to confirm that an adenovirus is indeed the primary causative agent of HPS since this information is crucially important to developing the most effective vaccine. This work should be continued, but with greater collaboration with other avian virus laboratories to help bring it to a fruitful conclusion.

BOSTID PROJECT SUMMARY
GRANT #10

Title: Genetic Improvement of Sunflower Crop for Production Under Saline Conditions

Investigator(s): Dr. Medhet Kamil Hussain
Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad

Funds Awarded: $68,371 **Funds Spent:** $59,893*

Grant Period: 4/9/92-5/31/94

Project Objectives:

Over 70% of the edible oil consumed in Pakistan is currently imported. Sunflower, with its high oil content, is a most promising crop for increasing domestic production of edible oil. Since the only land available for new production is stressed by salinity and low moisture, this project had the overall objective of breeding and selecting sunflower for good production under these conditions. The specific objectives of the project were as follows:

1. To screen sunflower germplasm for improved seed germination and seedling growth under normal and saline-stressed conditions.
2. To determine the growth and development patterns of selected sunflower genotypes for screening under saline-stressed conditions.
3. To evaluate the genotypes selected in the field under saline conditions.
4. To identify stable genotypes, tolerant to saline stress and high yielding, which can be used to produce elite, open-pollinated populations for cultivation on saline-stressed lands.
5. To determine the reliability of different screening techniques for selection of germplasm tolerant to salinity and low moisture.

Project Status:

The project accomplished the research goals given above.

Accomplishments:

The project laboratory is now well equipped to generate information on sunflower production for edible oil. More than 300 genotypes went through initial selection, and half of these were then evaluated in field trials. Phenotypic correlations of growth parameters with ion accumulations and yield components suggest a mechanism for selection that may allow breeding and field trials to proceed more efficiently.

Publications:

The following papers have been published:

Science International 5(2):203-205, 1993:

- "Breeding Sunflower for Salt Tolerance: Genetic Variability for Seedling Vigor and Salt Tolerance in Sunflower (*Helianthus annuus* L.)"

Proceedings, All Pakistan Scientific Conference, 1992, Khanspur:

- "Breeding Sunflower for Salt Tolerance: Effect of Salinity on Growth and Development of Cultivated Sunflower (*Helianthus annuus* L.)"
- "Breeding Sunflower for Salt Tolerance: Genetic Variability for Yield and Yield Components for Salt Tolerance in Sunflower (*Helianthus annuus* L.)"

Proceedings, International Seminar on Seed, December 1992, Islamabad:

* This amount may be adjusted pending verification of the final expenditure report.

- "Breeding Sunflower for Salt Tolerance: Association of Seed Quality to Salt Tolerance in Sunflower (*Helianthus annuus* L.)"
- "Breeding Sunflower for Salt Tolerance: Physiological Basis for Salt Tolerance in Sunflower (*Helianthus annuus* L.) at Flower Initiation"

The following papers have been accepted for publication:
Proceedings, 2nd All Pakistan Scientific Conference, December 1993, Lahore:

- "Breeding Sunflower for Salt Tolerance: Physiogenetic Mechanism of Salt Tolerance in Sunflower (*Helianthus annuus* L.)"
- "Breeding Sunflower for Salt Tolerance: Association of Seedling Growth and Mature Plant Traits for Salt Tolerance in Cultivated Sunflower (*Helianthus annuus* L.)"

Science International:

- "Breeding Sunflower for Salt Tolerance: Physiological Basis for Salt Tolerance in Sunflower (*Helianthus annuus* L.) at Seedling Stage"

Collaboration:

This project was visited regularly by group advisors. In addition, there was a consultant visit by Dr. Michael Shannon, U.S. Salinity Laboratory, Riverside, California (April 13-24, 1993). There was also a grantee visit by Dr. Medhet Kamil Hussain to North Dakota State University (Dr. A. Schneiter), Fargo, and the U.S. Salinity Laboratory (Dr. Michael Shannon), Riverside, California (November 27 - December 25, 1992).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Li-Cor Inc. portable leaf area meter
- Buchler digital chloridometer
- Buck Scientific, Inc. flame photometer
- Standard Industries, Inc. sunflower thresher
- Isotemp oven with additional shelves

Problems:

A structural problem was the broad-based screening of very heterogenous germplasm. Most results will have to be verified in subsequent trials to ensure that selected traits are truly heritable.

Application of Research:

There has been insufficient time to determine whether the promising germplasm is economical for farmers. It seems reasonable to assume, however, that some accessions now in field trials will have sufficient yield under saline conditions so that qualified recommendations can be made in the next 1-2 years.

Future Support Needs:

The long-term goal of this work is to decrease Pakistan's dependence on imported cooking oil, while adding a "new" crop for the nation's farmers.

The most important aspect of the work from a breeding standpoint is correlation of seedling or flowering characteristics with salt-moderated yield phenomena. Such techniques could then be used to screen accessions more rapidly for use in salt-afflicted land. Collection and evaluation of new germplasm would be an important component of this activity.

The next stage--which could be undertaken simultaneously--involves field evaluation and selection for development of elite sunflower populations showing tolerance to salinity. Results would be transferred to extension agencies and farmers by establishing demonstration plots. Efforts involving farmers and private agencies could also be made in the future to develop salt-tolerant populations with higher seed yield and seed production.

BOSTID PROJECT SUMMARY
GRANT #11

Title: Development of Management Strategies to Increase the Productivity of Eroded Areas and Watersheds

Investigator(s): Dr. Shahid Ahmad
Water Resources Research Institute, National Agricultural Research Centre (NARC), Islamabad

Funds Awarded: $64,300 **Funds Spent:** $59,191*

Grant Period: 7/13/92-5/31/94

Project Objectives:

Water and wind erosion reduce the productivity of over 55 million hectares of land in Pakistan. Computer models can be used to increase the long-term productivity of this land by testing different management strategies, each tailored to specific conditions of climate, soil, vegetation, and socioeconomic requirements.

The overall objective of this project was to develop and test management strategies for eroded areas and watersheds. Computer models would be developed and field tested in the Pothwar plateau and other areas of Pakistan. The ultimate goal was to raise the income of small farmers by developing more profitable farming systems. The specific objectives of the study were as follows:

1. To identify low-cost water-harvesting techniques/structures/amendments suitable for growing forage, fruit, and forest plants.
2. To select appropriate forage, fruit, and forest plants for different conditions, including rainfall, soil moisture, and topography.
3. To develop low-cost farm reservoirs for supplemental irrigation and prepare guidelines for construction and use by the farming community.
4. To estimate the benefits of water harvesting; supplemental irrigation; and production of specific forest plants, forage, and fruit.
5. To identify management strategies appropriate for three levels of farmer investment capability.
6. To validate the best strategies with field trials.

Project Status:

This project has generally addressed its objectives.

Accomplishments:

The research conducted under controlled conditions for reducing seepage from earthen ponds has shown the potential to yield substantial benefits. Water loss from small earthen reservoirs can be significantly reduced using physical and biological methods. The treatments appear to be practical and the study carefully conducted. The techniques used would be of interest in many arid areas, and can have an impact in such lands where animals depend on precipitation.

Publications:

The following paper has been prepared for publication: "Reducing Water Seepage from Earthen Ponds: A Few Options."

The following paper has been published: Shafiz, M., A. Hassan, and S. Ahmad. 1994. "Soil Physical Properties as Influenced by Induced Compaction under Laboratory and Field Conditions." *Soil and Tillage Research* 29:13-22.

* This amount may be adjusted pending verification of the final expenditure report.

Collaboration:

This project was visited regularly by group advisors. In addition, there was a consultant visits by Dr. John Stednick, Department of Earth Resources, Colorado State University, Fort Collins, to Islamabad (January 2-13, 1994). A grantee visit was made by Dr. Shahid Ahmad to the Earth Resources Research Center (Dr. John Stednick) of Colorado State University, Fort Collins; to The Center for Advanced Decision Support for Water and Environment Systems at the College of Engineering and Applied Science of the University of Colorado, Boulder; and to the U.S. Department of Agriculture's South West Watershed Research Laboratory (Dr. Dave Goodrich) in Tucson, Arizona (January 15-February 1, 1994).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- AST Research, Inc. computer Premium Server 4/33
- Houston Instruments plotter
- Universal Automation Systems universal positioning system (UPS) w/standard peripherals and software
- Compucom external hard drive for computer
- Lexmark laser printer with warranty
- Epson scanner with adapter kit
- Connor tape drive for computer
- Heinrich plate tamper soil compactor

Problems:

Difficulties in acquiring appropriate and compatible software and hardware for the geographic information systems (GIS) component of this project led to delays in the purchase of the equipment. The goals of the principal investigator for purchasing equipment were not always compatible with the project, but the final result is a well-equipped laboratory for future studies, along with a staff trained to use the equipment.

The study design encountered difficulties with rodents burrowing into treatments and causing lateral movement of the water (piping and siphoning). Evapotranspiration losses were also not monitored.

Application of Research:

The work was well done and should be useful as a basis for recommendations on pond construction. The team has extended these findings to farmers. The principal investigator has dedicated hard work to ongoing studies, extension efforts, and future plans.

Future Support Needs:

This project could have an important impact on Pakistan's arid areas. However, further testing on producer properties must be completed for the full potential to be evaluated. The key need is to get the compaction and bioplastic techniques into common practice on farms. Also needed is continuing research to devise new and better techniques for sealing the farm ponds.

A follow-up study would involve investigating how ponds treated to reduce seepage would withstand periods of drying. Some may dry completely between times of storing water, and some pond treatments may hold up better than others. The impact of animal hooves on seepage also warrants close attention.

BOSTID PROJECT SUMMARY
GRANT #12

Title: Integrated Insect Pest Management Technology for Muskmelons in Stressed Lands

Investigator(s): Dr. G.A. Miana, Dr. Said Mir Khan
Gomal University, Dera Ismail Khan

Funds Awarded: $89,017 **Funds Spent:** $84,413*

Grant Period: 3/7/92-5/31/94

Project Objectives:

In Pakistan, muskmelon (*Cucumis melo* L.) is an important crop for both poor and wealthy farmers. As a good source of carbohydrates, vitamins, and minerals, it plays an important nutritional role in the diets of the local population. In D.I. Khan, muskmelon is a cash crop that obtains high prices. However, it is repeatedly subjected to serious damage by insect pests, particularly fruit flies, so that yields can be devastated.

The main objective of this project was to develop a strategy for integrated pest management of muskmelon to control the insect problem and so increase productivity. The specific objectives were as follows:

1. To study the population dynamics of red pumpkin beetle (*Aulacophora foveicollis*) and fruit flies (*Bactrocera* [=*Dacus*] spp.) on muskmelon.
2. To determine the optimal timing of insecticides for controlling red pumpkin beetles and fruit flies.
3. To evaluate the efficacy and residual activity of biological active botanical compounds indigenous to Pakistan.

Project Status:

The main objectives were addressed, but a more intense follow-up is needed over 3-4 years to complete the work.

Accomplishments:

The annual population cycles of two pestiferous fruit fly species were monitored, and spraying regimens were developed on the basis of these analyses. The researchers estimated and controlled fruit fly populations in a local situation. Trend data were reported for assorted (synthetic) pesticide treatments, all of which were successful in suppressing fruit flies in melon. A botanical (neem-based) pesticide was formulated using locally available materials, and laboratory-scale production begun.

The most notable accomplishment was analysis of the number of applications necessary to achieve satisfactory fruit fly control. This research yielded a practical result: with two well-timed sprays, growers can get 85% clean fruit rather than only 5%.

Publications:

The following paper has been prepared for publication: "Population Dynamics and Control of Melon Fruit Flies at Dera Ismail Khan."

Collaboration:

This project was visited regularly by group advisors. Two grantee visits were also made:

- Dr. G. A. Miana to the Florist and Nursery Crops Laboratory (Dr. James C. Locke) and the Sustainable Systems Laboratory (Dr. Aref A. Badul Baki), U.S. Department of Agriculture

* This amount may be adjusted pending verification of the final expenditure report.

(USDA), Beltsville, Maryland; and the Food and Feed Safety Research Laboratory (Dr. Deepak Bhatnagar) USDA, New Orleans, LA (March 12-26, 1994).

- Dr. Said Mir Khan to the University of Hawaii (Drs. Diane Ullman of the Department of Entomology and C.S. Tang of the Department of Environmental Biochemistry) and the USDA Tropical Fruit and Vegetable Research Laboratory on Hilo; and to the Department of Horticulture (Dr. Jules Janick and Dr. James Simon), Purdue University, Lafayette, Indiana, as well as the Indiana Muskmelon Extension Research Station (March 11-28, 1994).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Perkin-Elmer International HPLC liquid chromatograph
- Perkin-Elmer International HPLC liquid chromatograph accessories kit
- Perkin-Elmer International HPLC liquid chromatograph detector
- Hotpack environmental chamber
- Labline environmental chambers (3)
- Advance American Technologies computer 486/66
- Cole-Parmer Instrument Company analytical balance
- Forestry Suppliers, Inc. insect drawers (24)

Problems:

The researchers did not fully accomplish the studies anticipated from the well designed set of objectives. In addition, the population-dynamics data were sufficient only to indicate trends because of the short time period of the study and the problems noted below.

Application of an inappropriate pesticide emulsifier destroyed one test planting of melons, so that a season's data were lost. There was very little information generated on control of red pumpkin beetle and on the use of indigenous botanical compounds for either pest.

The environmental chamber requested turned out to have a heating but not a cooling unit, which was unsuitable for the high summer temperatures in D.I. Khan. A second chamber was sent, but insect growth studies were deferred.

It is possible that some research results (especially with botanicals) have not been reported because of concerns over intellectual property rights.

Finally, the researchers did not adequately focus the project on objectives and procedures or accomplish the work anticipated largely because of a lack of coordination. Clashes between the principal investigator and co-principal investigator brought the project to a near standstill during a peak research season.

Application of Research:

The field results of the project are not sufficient at this time to yield more than general recommendations for pest control. Nonetheless, these results are a significant contribution to farmers in the study area. In the longer run, strategies and techniques could be developed to reinstate muskmelon as the pre-eminent horticultural cash crop of the area.

It is possible that a proprietary, locally produced botanical pesticide will be marketed.

Future Support Needs:

Muskmelons are well suited to this region, but recently introduced fruit flies have dramatically reduced production. Any improvement in pest control while reducing dependence on expensive synthetic pesticides would be a significant advance for the small farmers who produce melons as a cash crop. Such progress will depend on continued (and expanded) field and laboratory efforts of the type already under way.

For muskmelon to become a more important cash crop in this area, better lines must be identified and introduced. Currently, seeds are harvested and planted the next year; the cultivars could be thousands of years old. Although they probably have some natural resistance, especially to pathogens, quality varies widely and some have poor taste. Consideration could be given to improving local

cultivars for local consumption and using elite germplasm (with resistance to local pests and plagues) to develop an eventual market crop.

BOSTID PROJECT SUMMARY
GRANT #13

Title: Selection of Mesquite for Production of Grazable Biomass and Fuelwood in Stressed Land

Investigator(s): Dr. Rafiq Ahmad
Biosaline Research Laboratories, University of Karachi

Funds Awarded: $71,700 **Funds Spent:** $65,209*

Grant Period: 4/1/92-5/31/94

Project Objectives:

Millions of hectares in Pakistan are not productive because good-quality water is not available. Livestock in these areas survive on poorly growing wild flora, which is of minimal nutritional value. Mesquite (*Prosopis*) offers promise for lands stressed by salinity and inadequate amounts of water; it can provide both forage and fuelwood, and previous work has produced salt-tolerant species.

The main objective of this project was to identify and test promising *Prosopis* species for (1) tolerance to salinity and low rainfall, and (2) productivity in terms of forage and fuelwood on barren, sandy land. The specific objectives of the study were as follows:

1. To collect and screen local and exotic *Prosopis* species/lines for their grazable biomass and fuelwood production at sandy strata using saline water for irrigation.
2. To evaluate biological nitrogen fixation potential vs. biomass production in selected salt-tolerant *Prosopis* species.
3. To compare the biomass and fuelwood potential of promising *Prosopis* species with that of the existing plant species to determine the economic viability of the technology developed.

Project Status:

The project objectives have been largely completed. Evaluation of new *Prosopis* varieties requires a year or more of additional growth.

Accomplishments:

A large collection of salt-tolerant *Prosopis* germplasm was assembled, some of it unique. Laboratory and field experiments are well under way to measure saline tolerance, growth, and plant development. The data were carefully obtained and organized in detail. Several novel approaches were developed for producing useful biomass economically under exceptionally harsh conditions. The results of the various components of this project show promise for mesquite cultivation as a source of fodder, fuelwood, and timber; a source of high-value products; and a means to halt the movement of sand dunes in areas where good-quality water is not available. The investigators are considering a number of applications for *Prosopis*.

Publications:

The following papers have been prepared for publication:

- "Effect of Salinity on Growth of *Rhizobium* spp., Nodulation and Height of *Prosopis* Species"
- "Screening of Mesquites (*Prosopis* spp.) for Biomass Production in Barren Sandy Areas Using Highly Saline Water for Irrigation"

Award Received:

This project received the Award for Development of Innovative Applications from Research.

* This amount may be adjusted pending verification of the final expenditure report.

Collaboration:

This project was visited regularly by group advisors. In addition, there was a consultant visit by Dr. Peter Felker of the Center for Semi-Arid Forest Resources, Texas A&I University, Kingsville, to the University of Karachi (October 8-11, 1992). There were also several grantee visits:

- Dr. Rafiq Ahmad to the Center for Semi-Arid Forest Resources (Dr. Peter Felker), Texas A&I University, Kingsville (July 31-August 16, 1993)
- Dr. Shoaib Ismail to the U.S. Salinity Laboratory (Dr. James Poss), Riverside, California; the Water Management Research Laboratory (Drs. Gary Banuelos and Clarence Finch), U.S. Department of Agriculture, Fresno, California; the Department of Food and Agriculture (Dr. Vashek Cervinka), University of California, Davis; the Desert Legume Project (Drs. Matt Johnson and R. Phillip Upchurch) and San Pedro Mesquite Company, Tucson; the Department of Plant Sciences (Dr. James O'Leary) and Office of Arid Land Studies (Dr. Ken Foster), University of Arizona, Tucson; and Texas Kiln Products in Bastrop and Mesquite Products of Texas in Bulverde, Texas (April 17-May 2, 1994)
- Drs. Rafiq Ahmad and Shoaib Ismail to the Zayed Arid Zone and Environmental Research Centre (Dr. Ahmed Al-Masoum), Al-Ain University, and the Ministry of Agriculture and Fisheries (Dr. Hashim), Dubai, United Arab Emirates; the Arid Zone Research Centre (Dr. Shahta O. Al-Khatieb) of Gulf University and the Biology Department (Dr. Jameel Abbas) of Bahrain University, Bahrain; and the Ministry of Agriculture (Mr. Ali Hashim, Director, Soil and Water Section), Doha, Qattar (May 28-June 6, 1994)

In addition, Dr. Rafiq Ahmad attended the International Conference on Desert Development, Mexico City (July 22-30, 1993).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Geonics Limited ground conductivity (salinity) meter
- Li-Cor Inc. portable leaf-area meter
- Precision Systems micro-osmometer
- Li-Cor Inc. transparent conveyor belt
- AIRMAD plant water potential apparatus

Problems:

Research on salt tolerance in *Rhizobium* did not lead to usable results; however, it did generate interesting data and prevent misdirection of future research.

Because of damage by rabbits, some budwood was lost before the grafts were successfully established. As most germplasm was duplicated, the losses were in the range anticipated.

Because of a combination of technical, staffing, and financial circumstances, it was not possible to purchase an advanced saline drip irrigation system for the team's new field laboratory. Custom-assembled equipment for an advanced saline drip irrigation system was located in April 1994, but this was too late for purchase and shipment to be completed.

Application of Research:

This research could have a significant impact in several areas:

- To stabilize erodible sandy areas.
- To provide cottage industries (charcoal and value-added wood products) for people living on the margins of productive lands.
- To provide much-needed browsing and nutrients for free-ranging small ruminants.
- To produce high-value wood products.

The researchers have energetically explored traditional and innovative uses for *Prosopis* and show promise for completing one or more of these applications. Currently, they are working on techniques to improve charcoal production in areas where *Prosopis* is already available.

Future Support Needs:

This research is founded on years of experience, and shows continuing potential for affecting large numbers of people. During the study period, a modern field laboratory was constructed using other funding. It provides an excellent site for further germplasm characterization and selection. The livestock component would be enhanced by addition of a consulting range-animal scientist. An industrial component merits special long-term attention; mesquite can become a very desirable specialty wood that could be grown sustainably on areas that are currently unproductive.

BOSTID PROJECT SUMMARY
GRANT #14

Title: Biocontrol of Chickpea Pod-borer

Investigator(s): Dr. Bashir Ahmed Malik
National Agricultural Research Centre, Islamabad

Funds Awarded: $62,860 **Funds Spent:** $61,790*

Grant Period: 3/30/92-5/31/94

Project Objectives:

Chickpeas are grown on about 1 million hectares in Pakistan and produce about 500,000 million tons annually. They are the main source of protein for the rural population. The yields of about 0.5 metric ton per hectare are among the lowest in the world, mainly because of low moisture, disease, and insect stress. Chickpea pod-borer (*Helicoverpa [Heliothis] armigera* [Hübner]) is the major insect pest.

The overall objective of this project was to identify potent strain(s) of *Bacillus thuringiensis* Berliner for the control of chickpea pests, particularly chickpea pod-borer, and include them in an integrated pest management program, thereby reducing reliance on pesticides. The specific objectives were as follows:

1. To document the incidence of Bt infections that occur naturally in lepidopterous pests, particularly *Helicoverpa* spp., in Pakistan.
2. To use bioassays of indigenous and exotic Bt strains to establish their potency against *H. armigera*.
3. To test the efficacy of one or two of the most toxic Bt strains against the chickpea pod-borer as part of an integrated control strategy (Bt field experiment).

After the initial site evaluation, the above objectives were modified so that major emphasis of the project was to evaluate existing commercially available materials and isolates. Close links with private (non-Pakistani) industry would be necessary to access new technologies that would allow quick evaluation of new isolates and identify those that may have activity.

Project Status:

The modified objectives have been accomplished, except the field trials, which will continue for a few more seasons.

Accomplishments:

The researchers produced valuable results under the modified objectives: they measured various commercial Bt isolates, established stage-specific potencies for Bt, found they were cost-effective, and developed a good application regimen. They also did good work in implementing the field trials.

The project's well-designed and -executed studies developed interesting and useful results relating the phenology of crops and pests, so that applications of Bt could be targeted to specific times. Local life-cycle studies of *Helicoverpa* were integrated into plant protection methods, and publishable information on the varying potencies of commercial preparations of Bt was obtained. In addition, more than 100 Bt strains native to Pakistan were isolated, and an efficient and cost-effective diet for mass rearing of chickpea pod borers was developed (a requisite for toxicology testing on this important insect pest).

* This amount may be adjusted pending verification of the final expenditure report.

Publications:

The following papers have been prepared for publication in international journals:

- "Modified Artificial Diet for Mass Rearing of Chickpea Pod Borer, *Helicoverpa* (*Heliothis*) *armigera* (Hübner)"
- "Susceptibility of Larval Instars of *Helicoverpa* (*Heliothis*) *armigera* (Hübner) to HD-1-S-1980 and Relative Toxicities of Commercial *Bacillus thuringiensis* Berliner"

There have also been a large number of papers prepared for PARC.

Award Received:

The project received an Award for Scientific Excellence and Leadership. The team of Dr. Bashir Malik and Mr. Khalique has performed in an exceptionally collegial manner, providing the mutual support so important to collaboration between a breeder and an entomologist. Further, full and appropriate credit was given to the responsible researchers on the team.

Collaboration:

This project was visited regularly by group advisors. A grantee visit was made by Dr. Khalique Ahmed to Dr. David Riley, Texas A&M University, Weslaco, Texas (November 2-22, 1993).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Hotpack environmental chamber
- AST Research, Inc. computer with software and mouse
- Lab-Line Instruments plant growth chamber
- Lexmark laser printer with warranty
- Waring blender/stirrer

Problems:

The original environmental chamber did not have refrigeration. It was replaced with another model, but rearing studies were delayed. The first chamber can be used for growing plants.

Application of Research:

The newly developed mass-rearing diet should prove valuable to those engaged in *Helicoverpa* research. Correlating *Helicoverpa* life-stages with crop phenology (especially through use of pheromone traps) should lead to effective field use of Bt. Studies of Bt residual effects could clarify the need for multiple Bt applications. The new information derived from this project could greatly increase the production of chickpea without disrupting the basic ecology of the chickpea production system.

Future Support Needs:

A few more years of field trials could develop even more effective integrated pest-management strategies against chickpea pests, which could lead, in turn, to important increases in the production of this important leguminous crop. Future studies could also lead to the isolation of new and effective strains of Bt from materials collected during this research. A promising direction for additional research is development of the technology for in-country toxin production.

BOSTID PROJECT SUMMARY
GRANT #15

Title: Development of Wheat and Barley Varieties for Rotation with Rice in Moisture-Deficient and Saline Soils in Sindh

Investigator(s): Dr. Muhammad Ismail Memon
Wheat Research Institute, Sakrand, Tandojam, Sindh

Funds Awarded: $17,900 **Funds Spent:** $6,657*

Grant Period: 11/30/92-5/31/94

Project Objectives:

Wheat and rice are major crops in Pakistan. Both are particularly important in Sindh province, where almost 700,000 hectares is in rice production with a wheat/barley rotation. There are two major problems:

- Although the area is serviced by canals, no irrigation water is available for winter crops of wheat and barley.
- The wheat must be planted late because it is in rotation with rice varieties of long duration.

The overall objective of this project was to contribute to the development of an improved rotation system using superior varieties of wheat and barley selected for (1) short duration, (2) tolerance to the moisture-stressed conditions in upper Sindh, and (3) tolerance to the saline conditions of lower Sindh. The specific objectives of the study were as follows:

1. To test identified short-duration lines/cultivars for moisture stress conditions, to be grown in winter on residual moisture following rice.
2. To test and develop technology for rice-wheat/barley rotation in order to study the productivity potential of wheat and barley varieties/cultivars identified/developed during the study.
3. To compare the socioeconomic potential of new technologies relative to existing practices.

Project Status:

It is necessary to complete objective 1 before objectives 2 or 3 can be undertaken. Nearly 150 varieties of wheat have been tested in field trials, but selection of superior varieties will take 3 years according to the advisor, Dr. Oster. Thus selection of varieties should be complete within the next year. The next step (objective 2) involves using the superior varieties to develop and test cultural practices. Objective 3 is an economic comparison of different practices.

Accomplishments:

Nearly 150 wheat and barley varieties have been tested for suitability for winter growth on residual moisture from summer rice crops. The work appears to be scientifically valid, and the trial results to date provide important information for growers in the Hyderabad region. Based on this research, the project team plans to start a preliminary seed multiplication program and agronomic-practice trials at the beginning of this year's growing season.

Publications:

The following paper has been prepared for publication but will require additional seasons of data: "Development of Wheat and Barley Varieties for Rotation with Rice in Moisture-Deficient and Saline Soils of Sindh."

* This amount may be adjusted pending verification of the final expenditure report.

Collaboration:

This project was visited regularly, but in Karachi, because of security concerns in the area.

Major Equipment Received:

No equipment was purchased for this project.

Problems:

This project has had three principal investigators because of changes in the directorship of the Wheat Research Institute: Dr. Mohammad Raza Lodhi, Dr. Karam Khan Kaleri, and now Dr. Muhammad Ismail Memon. With this lack of continuity, progress has been limited. The data set is insufficient to yield robust conclusions.

Application of Research:

The information this project will eventually produce is important for local farming: knowledge of varietal performance under specific conditions is necessary for a successful agricultural system. Variety performance data are best disseminated as a research report to a targeted group, with the best varieties being demonstrated in the field.

Future Support Needs:

Variety trials become more valuable as the number of trials over a period years increases. Because of variations among growing seasons, several years are usually necessary to evaluate performance adequately. Therefore, the varietal evaluation reported represents only the first of several years' work necessary to adequately characterize varietal performance.

Regrettably, all harvesting is done by hand; purchase of a new threshing machine would be a priority if this project receives more funding. Continuity in leadership is also critical if the project is to receive the attention it deserves.

BOSTID PROJECT SUMMARY
GRANT #16

Title: Potassium and Ammonium Dynamics in Soil and the Implications for Fertility Management

Investigator(s): Dr. M. Saleem Akhtar
Land Resources Research Institute, National Agricultural Research Centre (NARC), Islamabad

Funds Awarded: $70,700 **Funds Spent:** $68,325*

Grant Period: 6/13/92-5/31/94

Project Objectives:

The limited availability of potassium (K) and ammonium (NH_4) to growing crops has become a major constraint on crop production in Pakistan. The reduced efficiency of fertilizer appears to be due to poor release of mineral K and to fixation of fertilizer K and NH_4. The mineral composition of soil is a significant factor in efficient utilization of K and NH_4 fertilizers.

The overall objective of this project was to identify and quantify the mineral phases of agricultural soils in Pakistan and to characterize those pertinent to K and NH_4 dynamics in the soil system. The specific objectives were as follows:

1. To identify and quantify the various mineral phases in agricultural soils.
2. To determine relationships between soil mineralogy and the quantity and intensity of nutrients available.
3. To determine K release and K and NH_4 fixation potential of the various soil size fractions.
4. To correlate mineralogy, K and NH_4 chemistry, and the quantity and intensity of nutrients with crop responses in greenhouse and field experiments using selected soils.

Project Status:

The first three objectives were completed, while the last was postponed when the project time was reduced to 2 years.

Accomplishments:

Benchmark soils from several agricultural areas were selected and characterized for mineralogical composition, including complete fractionation, chemical analysis, and K release of sand and clay, as well as K and NH_4 fixation. The K quality-intensity relationships of the upper four horizons of all the soils were developed. The project team's careful and thoughtful research--during which three students received soil-science training in-country--has resulted in an large body of new and useful knowledge about K behavior in soils. This information will facilitate the development of efficient K (and perhaps NH_4) fertilizer strategies, and will provide basic reference data for the testing of more rapid methods of characterizing the K fertility status of soils.

Publications:

The following technical papers have been prepared for publication:

- "Potassium Release Characteristics of Sand and Silt in Relation to Mineralogy: I. Selected Mollisols, Vertisols, and Inceptisols"
- "Potassium Release Characteristics of Sand and Silt in Relation to Mineralogy: II. Selected Alfisols and Aridisols"
- "Clay Mineral Composition and Characteristics of Soils in Relation to Potassium Chemistry: I. Mollisols and Vertisols"

* This amount may be adjusted pending verification of the final expenditure report.

Collaboration:

This project was visited regularly by group advisors. A grantee visit was also made by Dr. M. Saleem Akhtar to the Department of Soil and Crop Sciences (Dr. Joe Dixon), Texas A&M University, College Station (December 4, 1993-January 13, 1994). In addition, Dr. M. Saleem Akhtar attended the 10th International Clay Conference, Adelaide, Australia (July 18-26, 1993).

The researchers also determined bulk density and moisture changes due to tillage treatments for Project #27.

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Labconco Corporation freeze-dry system
- Branson cell disruptor
- Lexmark laser printer with memory upgrade, software & warranty
- Fisher Scientific ion-selective electrodes (Ca & Mg, K, Na, Cl, and Reference)
- VWR Scientific vacuum pump for freeze dryer system
- Beckman thermocouple for infrared spectrophotometer

Problems:

Some essential equipment and chemicals arrived late, which delayed some of the research activities. Computer analysis of the data would have considerably reduced the required labor.

The data analyses were not complete enough by the end of the project to explain relationships with chemically extracted K for correlation with plant growth, or to explain the lack of crop response to K fertilizer on K-deficient soils.

The hypothetical approach of this group to K fertility is rigid and excludes parameters that others consider important; thus the results obtained are often deemed incomplete by peer reviewers. For this reason, communication and collaboration of the group with other experts in soil fertility is important and should be given high priority.

Application of Research:

The reduced time for the project eliminated the opportunity to evaluate the applicability of the research. However, these data should be most valuable to Pakistan's researchers and others working on similar soils. The information will be particularly useful if the nonavailability of K can be explained.

Future Support Needs:

The kinetics of K release should be completed, and the relationships between K and NH_4 fixation remain to be addressed.

Because of the shortened project time, greenhouse studies were not undertaken. The researchers have conducted this type of study before and plan to continue with the soils characterized in this project; these studies need to be done. The next steps should validate or invalidate the principal investigator's exclusively soil-based hypothesis, which would be of general interest to the subdiscipline.

BOSTID PROJECT SUMMARY
GRANT #17

Title: Insect Pest Management in Stored Grain and in the Rice Crop Using Botanical Products

Investigator(s): Dr. Noor Ullah, Mr. S.A.R. Kazmi
Tropical Agricultural Research Institute, Karachi
(Original PI was Dr. Ghulam Jilani)

Funds Awarded: $60,400 **Funds Spent:** $43,778*

Grant Period: 6/10/92-5/31/94

Project Objectives:

Ecological and environmental problems associated with indiscriminate use of synthetic pesticides have necessitated the development of alternate pest control strategies. Numerous traditionally used plants such as sweetflag (*Acorus calamus*), neem (*Azadirachta indica*), turmeric (*Curcuma longa*), and artemesia (*Artemisia dubia*), as well as extracts from the marine animals *Zoanthid* species and *Aplysia juliana*, are potential sources of materials or chemicals for pest control.

The major objective of this project was to develop alternate pest control products of natural botanical origin to reduce losses caused by insect pests and minimize the problems associated with the indiscriminate use of synthetic pesticides. This focus was on plants other than neem that have not yet been investigated for their potential in pest control. The specific objectives, revised early in the study, were as follows:

1. To evaluate biological activity of botanicals and marine animals against stored-grain insects under laboratory conditions.
2. To determine the efficacy of botanicals for controlling stored-grain pests on bagged rice.
3. To evaluate the efficacy of botanicals for controlling insect pests of rice under cultivation.
4. To identify active ingredients for crude extracts that show biological activity against stored grain insect pests.
5. To determine the mammalian toxicity of chemicals identified in objective 4.
6. To formulate active ingredients from botanicals to be used as botanical insecticides.

Project Status:

This project accomplished the above objectives, with the exception of objectives 4 and 6, which were the responsibility of the collaborating institution, H.E.J. Research Institute of Chemistry.

Accomplishments:

The current principal investigators pulled this project together when the first investigator moved. They did good work, particularly within the time available. The research yielded interesting and potentially useful information on several locally available natural pesticides. Although the effectiveness of the various extracts was not impressive--through no fault of the researchers--some significant protection of stored grain products was found under certain conditions.

Publications:

The following papers have been prepared for publication:

- "Repellency and Growth Inhibitory Effects of Indigenous Plant/Marine Animal Extracts Against Red Flour Beetle, *Tribolium castaneum* (Herbst) Coleoptera: Tenebrionidae"
- "Evaluation of Some Plant Extracts/Products Against White-Backed Plant Hopper, *Sogatella furcifera* (Horvath) Infestation on Rice"

* This amount may be adjusted pending verification of the final expenditure report.

- "Farm-Level Evaluation of Some Botanical Products as Protectants of Stored Rice Against Insect Attack"

Collaboration:

This project was visited regularly by group advisors. Two grantee visits were made:

- Dr. Noor Ullah to the University of Hawaii (Drs. Diane Ullman of the Department of Entomology and C.S. Tang of the Department of Environmental Biochemistry) and the U.S. Department of Agriculture (USDA) Tropical Fruit and Vegetable Research Laboratory on Hilo; and to the Department of Horticulture (Dr. Jules Janick and Dr. James Simon), Purdue University, Lafayette, Indiana (March 11-28, 1994).
- Dr. S.A.R. Kazmi to the Florist and Nursery Crops Laboratory (Dr. James C. Locke) and the Sustainable Systems Laboratory (Dr. Aref A. Badul Baki), USDA, Beltsville, Maryland; and the Food and Feed Safety Research Laboratory (Dr. Deepak Bhatnagar) USDA, New Orleans, Louisiana (March 12-27, 1994).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Jouan, Inc. refrigerated centrifuge
- Labconco Corporation freeze-dry system
- Welch vacuum pump for freeze-dry systems (2)

Problems:

This project suffered from the beginning because the first principal investigator, Dr. Jilani, insisted that two projects be funded- one to the H.E.J. Research Institute of Chemistry and one to the Tropical Agricultural Research Institute--and that each be funded at a high level ($150,000). The committee did not vote to duplicate the capabilities in these two institutions or to fund at the requested level. Rather, the members recommended that each institution use its current equipment and capabilities and limit the purchase of additional equipment. Theoretically, the capabilities of the institutions were complementary. However, Dr. Jilani accepted the $60,000 grant, was unwilling to pursue the project as defined, complained at every meeting, and did not get cooperation from H.E.J.

When Dr. Jilani left for another position, Dr. Noor Ullah and Mr. Kazmi became co-principal investigators. Progress was initially slow, but at the point where BOSTID was considering cancelling the project, they were able to show good progress that continued to the end of the project.

Attaining objectives 4 and 6 depended on input from H.E.J. Research Institute of Chemistry; this collaboration was promised in good faith, but was not delivered.

Because of the short time devoted to this research, the final data are incomplete and require additional trials. Moreover, insufficient attention was paid to the full spectrum of natural pesticides funded by the study. The primary focus remained on neem, a botanical on which considerable information is available from previous studies by these investigators.

Despite these difficulties, the investigators prepared three papers.

Application of Research:

At this stage, application of the project results is not economically attractive. Nonetheless, some interesting extractions were made and useful data generated. The data have good integrity. This type of botanical research is necessary to ensure that potential pesticides are effective and compatible in integrated pest-management programs.

Future Support Needs:

More work--especially screening--is required to find indigenous pesticides, test their efficacy, and calculate their efficiency. The success rate for this type of research is surprisingly low, but when effective materials and techniques have been identified, the payoff has traditionally been enormous.

BOSTID PROJECT SUMMARY
GRANT #19

Title: Contribution of Biological Nitrogen Fixation to Rice grown on Salt-Affected Soils

Investigator(s): Dr. Kauser A. Malik
National Institute for Biotechnology and Genetic Engineering, Faisalabad

Funds Awarded: $84,020 **Funds Spent:** $90,412*

Grant Period: 6/24/92-5/31/94

Project Objectives:

Rice is an important crop for Pakistan and is grown on a large area in Punjab and Sindh provinces. Increasing efforts are being made to grow rice on salt-affected soils. Numerous dinitrogen-fixing bacteria have been isolated from grasses, including rice, growing in saline soils. Also, *Azolla* and blue-green algae have been collected from numerous habitats in the Punjab. All of these nitrogen-fixing systems play a role in maintaining the nitrogen fertility of paddy soils.

The main objective of this project was twofold: (1) to assess and optimize the contribution of biological nitrogen fixation to the growth and nutrition of rice grown on salt-affected soils, and (2) to develop appropriate technologies for utilizing biological nitrogen fixation as a source of nitrogen fertilizer for rice and subsequent crops. The specific objectives of this study were as follows:

1. To identify various salt-tolerant varieties/cultivars of rice that would stimulate nitrogen fixation.
2. To select and improve the salt tolerance of *Azolla* strains and assess their optimal utilization and contribution to rice yields.
3. To quantify the nitrogen contribution of *Azolla* as a basal/intercrop and a green manure using 15N-dilution methodology.

Project Status:

The objectives of the project were addressed: N^{15} and other studies were completed, while different varieties of *Azolla* were monitored, in pots, for salt resistance.

Accomplishments:

This research yielded a scientifically sound contribution on biological nitrogen fixation. Of particular significance is the information on plant-bacteria-auxin interactions showing auxin-like effects of indoleacetic-acid-producing rhizobacteria on nitrogen fixation and uptake. On a more practical level, the results of the microplot field experiment demonstrated once again the importance of associative nitrogen fixation: the presence of *Azolla* helps in reducing nitrogen losses and increasing fertilizer efficiency.

Publications:

The following paper has been prepared for publication: "Role of N_2-Fixing and Growth Hormone-Producing Bacteria in Improving Growth of Wheat and Rice."

In addition, research presentations were made at the following conferences:

- International Congress on Nitrogen Fixation, Cancun, Mexico, December 1992
- 6th International Symposium on Nitrogen Fixation with Non-Legumes, Ismailia, Egypt, September 1993
- International Symposium on Biotechnology for Sustainable Development, Faisalabad, Pakistan, December 1993

* This amount may be adjusted pending verification of the final expenditure report.

Award Received:

This project received a Certificate of Merit for Excellent Poster at the Final Conference of the BOSTID-PARC Research Program.

Collaboration:

This project was visited regularly by group advisors. Two grantee visits were also made:

- Dr. Kauser Malik to Washington State University (Dr. Thomas Lumpkin), Pullman, and Dr. Dwight Baker, Panlabs, Seattle (November 28-December 2, 1992); also to the Department of Agronomy and Range Science (Dr. D. William Rains), University of California, Davis (December 13-15, 1992)
- Mr. Sikander Ali to the Department of Natural Sciences (Dr. William Zimmerman), Michigan State University, Dearborn (May 28-July 29, 1993)

The following conferences were attended:

- Dr. Kauser Malik to the 9th International Congress on Nitrogen Fixation, Cancun, Mexico (December 3-12, 1992)
- Mr. Sikander Ali to the 6th International Symposium on Nitrogen Fixation with Non-Legumes, Ismailia, Egypt (September 6-10, 1993)

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Leica, Inc. microtome with quick-release clamp
- Labconco Corporation still
- Wheaton autostill
- AST Research, Inc. computer with software and mouse
- Cole-Parmer Instrument Company shaker bath
- Cole-Parmer Instrument Company spectrophotometer
- Hewlett-Packard scanner
- Cole-Parmer Instrument Company one channel recorder
- VWR Scientific pH meter
- Lab-Line Instruments orbital shaker

Problems:

There were no significant problems in this project.

Application of Research:

Based on microplot field trials of laboratory results, the research indicated that use of biofertilizers along with a low input of chemical-nitrogen fertilizer is useful for increasing rice yield, for increasing the efficiency of fertilizer nitrogen, and for increasing the contribution of biological nitrogen fixation to meet the needs of rice grown in saline soils. The researchers are negotiating with agribusiness companies in Pakistan to assist in extension of these technologies to farmers.

Future Support Needs:

Rhizosphere ecology work is still in the early stages. The researchers plan to continue basic attachment and colonization studies, and to expand their *Azolla* work to cooler geographical areas.

BOSTID PROJECT SUMMARY
GRANT #20

Title: Development of Protoplast Technology for Indica Rice

Investigator(s): Dr. Yusuf Zafar
National Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad

Funds Awarded: $68,900 **Funds Spent:** $69,175*

Grant Period: 6/24/92-5/31/94

Project Objectives:

Rice is a major crop of Pakistan. It is increasingly being produced on salt-affected soils, yet it remains relatively sensitive to salt concentration. Elsewhere, research on the japonica subtype of rice has permitted the application of recombinant DNA technology and protoplast fusion to programs of rice improvement. In Pakistan, indica rice is the cultivar of choice, yet *in vitro* manipulation has not been accomplished for this cultivar.

The major objective of this project was to develop efficient regeneration systems of local cultivars of indica rice, as well as wild rice cultivars, that would ultimately allow production and selection of cultivars or fusion hybrids tolerant of the environmental stresses common in Pakistan. The specific objectives of this study were as follows:

1. To obtain routine and reproducible regeneration of protoplasts of local cultivars of indica rice (*Oryza sativa*).
2. To identify the parameters for routine protoplast regeneration of available species of wild rice.
3. To optimize conditions for somatic hybridization between indica rice and wild rice species through chemical means or electroporation.
4. To optimize conditions that would allow DNA transformation of regenerating protoplasts of indica rice.

Project Status:

This is a difficult project, and the team has made some progress toward the final goal. The most important steps involved (1) construction of a ballistic gun and testing to demonstrate that it works and (2) experience for Mr. Zahid Mukhtar at the International Rice Research Institute (IRRI).

Accomplishments:

The regeneration of rice protoplasts to produce callus and plants is technically difficult. To be successful, it requires painstaking attention to a large number of variables and needs to be carried out on a large scale. Even when established in the laboratory, the technology is fragile and not easily transferred to breeders. Although modest, the accomplishments of this project in working with seven different cultivated rice genotypes and four other species of rice are important and useful. At the same time, the investigators have successfully applied the biolistic method for transformation and have obtained expression of marker genes.

Publications:

The project resulted in the following publications and presentations:

- "Transgenic Rice--A reality within reach" (abstract)
- "Establishment of Regeneration of Calli and Cell Suspension Line of Basmati Rice (*Oryza sativa* L. cv B.370)," in *Pakistan Journal of Botany*

* This amount may be adjusted pending verification of the final expenditure report.

- "In-vitro studies of wild rice: Development of cell and protoplast cultures of *Oryza glaberrima* Stend.," paper presented at the 3rd National Meeting of Plant Tissue Culture, August 2-5, 1993, Baragali, Pakistan
- "Development of In-Vitro Techniques for the Improvement of Local Indica Rice," *Proceedings of the International Symposium on New Genetical Approaches to Crop Improvement* (in press)
- "Micro Calli from Basmati 370 (*Oryza sativa* L cv. Basmati B.370) Protoplasts," *Pakistan Journal of Scientific and Industrial Research* (submitted)

Collaboration:

This project was visited regularly by group advisors. Two grantee visits were made:

- Dr. Yusuf Zafar to the International Rice Research Institute, Los Banos, Philippines (February 6-11, 1993)
- Mr. Zahid Mukhtar to the International Rice Research Institute, Los Banos, Philippines (September 1993 to May 1994).

In addition, two conferences were attended:

- Dr. Yusuf Zafar to the 6th Annual Meeting of the Rockefeller International Program on Rice Biotechnology, in Chiang Mai, Thailand (February 1-5, 1993)
- Mr. Zahid Mukhtar to the 7th Annual Meeting of Rockefeller International Program on Rice Technology, in Bali, Indonesia (May 16-20, 1994).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- BTX Inc. electroporation system
- Eberbach Corporation rotary shaker

Problems:

Cell/protoplast culture and transformation technology are relatively new in Pakistan, and the problems encountered in such a specialized area are enormous. This project faced a number of specific problems:

- The period of support was too short to expect major achievements from the work.
- The project suffered as a result of losing one of its principal investigators, Mr. Wajid.
- Supplies with a non-U.S. origin--particularly specific enzyme preparations from Japan--had to be processed through a long and cumbersome process, so that the first request was badly delayed, and the second was not approved.
- Equipment was not available at the time it was needed.
- On the biological side, because of the absence or low frequency of regeneration, transgenic plants have yet to be obtained.

Application of Research:

Transformation is a tool of interest primarily to plant breeders. This research is still a long way from providing such a tool. It is also not clear which rice breeders it is designed to help and what they might seek from it.

Future Support Needs:

The application of transformation technology in rice improvement has been slow to develop everywhere because of the technical difficulties involved in evaluating it. It would be wise to see what use would in fact be made of additional results and which rice breeding programs would benefit thereby. An alternative is to consider some other projects for this small group of experienced and capable plant tissue culture experts to undertake that may have greater practical significance for Pakistani agriculture.

BOSTID PROJECT SUMMARY
GRANT #21

Title: Developing a Fertility Management System for Eroded Lands

Investigator(s): Dr. Amanullah Bhatti
North West Frontier Province Agricultural University, Peshawar

Funds Awarded: $23,240 **Funds Spent:** $28,183*

Grant Period: 6/29/92-5/31/94

Project Objectives:

Soil erosion has a profound effect on the physical and chemical properties of soil and its productivity. Management practices to restore crop productivity on eroded land must allow for soil properties and production potential. The overall objective of this project was to conduct extensive soil sampling at regular grid spacing on selected commercial/government farms having an erosion problem, obtain data on soil properties and crop productivity, and establish novel management plans. The specific objectives of this study were as follows.

1. To determine the changes in soil properties due to past erosion that are responsible for loss in crop yield.
2. To identify limiting factors of crop production of these eroded lands.
3. To develop efficient fertility management strategies to restore the productivity of eroded lands.

Project Status:

The above objectives have been accomplished.

Accomplishments:

The research team studied problems of soil fertility management using an interesting geostatistical approach to account for important spatial variability in slope, landscape position, and soil properties. The design took advantage of new statistical techniques which seem quite useful for fertility experiments conducted on large fields managed by farmers in areas where soils are variable. The results showed a correlation between yield and the erosional status of soils.

The first accomplishment was the design of a fertility experiment that takes advantage of geostatistical techniques. Variabilities in soil and crops were characterized during the first year of the two-year plan; the data from the first year were used to determine three zones in the field with different fertilizer requirements.

The project was conducted on a farmer's field, which resulted in an excellent transfer-of-information process: the farmer saw the effects of fertilizer on crop growth and had numerous opportunities to talk with the researchers. Information was transferred both from the researchers to the farmer and from the farmer to the researchers. Information on constraints faced by the farmer was valuable for the researchers who designed and conducted the experiments.

The researchers met tight cropping deadlines and established admirable rapport with local farmers.

Publications:

The following paper has been prepared for publication: "Using Geostatistics in Soil Fertility Research on a Field Scale."

* This amount may be adjusted pending verification of the final expenditure report.

Award Received:

The project received an Award for Excellence in Research Application and Collaboration with Other Researchers.

The principal investigator and team showed excellent responsiveness to the needs of the farmer and the applicability of the research project. In addition, the principal investigator made valuable contributions to another BOSTID research effort for which he had no formal responsibility. This award is particularly significant because this grant was one of the smaller projects.

Collaboration:

This project was visited regularly by group advisors. In addition, Dr. Amanullah Bhatti visited the Dryland Agriculture Institute Workshop at West Texas A&M University, Canyon, Texas (June 6-July 1, 1994), and then the Department of Soil Physics (Dr. David J. Mulla), Washington State University, Pullman (July 2-9, 1994).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Advance American Technologies computer 486/66

Problems:

Large data-collection efforts are required for experimental designs that use geostatistical techniques. This was a problem for the project because of its limited staffing.

Another problem was the significant travel required to reach the farmers' fields where research was conducted.

Finally, the principal investigator has been well trained, but needs experience in incorporating into his reports and papers findings from other researchers who have laid the groundwork in developing geostatistical techniques, as well as the application of those techniques in the soil and crop sciences.

Application of Research:

A major accomplishment of the project was the application of a novel methodology combining new mathematical techniques with old fertilizer-trial techniques to allow identification of spatial patterns and use of chosen criteria to divide fields into different management zones. Varying fertilizer applications based on yield patterns could result in improved fertilizer efficiencies and profit, and perhaps increased crop yields. This work could contribute significantly to understanding of the management of heterogeneous soil fertility. This technique may be applied in other studies.

Future Support Needs:

More years of data on several sites is necessary to complete this examination of spatial variation caused by erosion and deposition. Models would then be validated on different sites for their usefulness in predicting variability in different soil and landscape situations. Follow-up on these studies--especially in diverse climates--could demonstrate how improved management can result in savings for farmers.

This type of fertilizer experiment needs to be conducted on several different farm sites in the immediate future to expand the research team's experience, to provide training for students and extension staff, and to foster the adoption of crop production techniques that use the various options available (including rotations with legumes) to improve soil fertility.

In addition, Dr. Bhatti should write a review paper on the use and application of geostatistical methods for his Pakistani colleagues. This paper should be peer-reviewed by international experts.

BOSTID PROJECT SUMMARY
GRANT #22

Title: Crop management practices for improving crop productivity and soil fertility on marginal lands

Investigator(s): Dr. Mir Hatam
North West Frontier Province Agricultural University, Peshawar

Funds Awarded: $23,910 **Funds Spent:** $27,618*

Grant Period: 6/9/92-5/31/94

Project Objectives:

Wheat and chickpea are the major dryland winter crops in Pakistan, yet yields are low because of poor management practices and low soil fertility. The overall object of this project was to devise optimum management practices for increasing crop productivity and maintaining soil fertility levels for sustainable dryland farming. The specific objectives of this study were as follows:

1. To determine an optimum rate and method of nitrogen (N) and phosphorus (P) fertilizer application to wheat and chickpea.
2. To quantify the effect of organic manure on the productivity of wheat and chickpea.
3. To determine the most suitable combination of organic and inorganic N and P fertilizers for maximum sustainable yields.
4. To determine the effect of crop rotations on crop yield and soil fertility for prolonged sustainable agriculture.

Project Status:

The above objectives were accomplished. In fact, results from the initial experiments led to experiments beyond those originally planned. Application of farmyard manure increased crop yields both in chickpea trials and in one wheat trial. In the other wheat trial, yields were decreased, possibly because of low rainfall or disturbance of the carbon/nitrogen (C/N) ratio. The next season, the applications of farm manure were extended to more levels and included more levels of fertilizer as well.

Accomplishments:

The researchers maintained their focus on developing a cost-effective way to increase crop production using abundant, unused manure. As noted, however, use of manure did not provide consistent results: negative impacts on yields were observed in several locations. Crop production systems based on manure require knowing how to manage high C/N ratios and the negative impacts on available N that can result.

Use of inorganic fertilizer (N and P) resulted in profitable yield increases in experiments at several sites. The yield response function to N was linear, indicating that higher rates of N should be included in future studies.

The yield increases obtained using N on chickpea indicate that the N fixed by the crop is not adequate for its use.

Publications:

The following paper has been prepared for publication: "Response of Wheat and Chickpea to Organic and Inorganic Manures in Rainfed Agriculture."

* This amount may be adjusted pending verification of the final expenditure report.

Collaboration:

This project was visited regularly by group advisors. The following grantee visits were made:

- Dr. Mir Hatam to the International Center for Agricultural Research in Dry Areas (ICARDA) in Aleppo, Syria (April 21-28, 1993)
- Dr. Mir Hatam and Dr. Aslam Khan to the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) in Patancheru, Andhra Pradesh, India (December 8-16, 1993)

In addition, Dr. Mir Hatam attended the Dryland Agriculture Institute Workshop at West Texas A&M University, Canyon, Texas (June 6-July 1, 1994). Dr. Mir Hatam and Dr. Aslam Khan attended the International Symposium on Pulses in Kanpur, India (December 4-8, 1993).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Advance American Technologies computer 486/66

Problems:

A general problem was that there was not adequate time to conduct the research under this project.

In addition, test sites for the project had to be changed because of political disturbances in tribal areas. This and the fact that the initial experimental design did not include high enough levels of N and P led to results that are not definitive and require more trials over more years.

The results obtained in the manure treatments indicate a need to study the literature to learn the crop/animal production systems that optimize the N cycle in terms of crop availability. In addition, characterization of the elemental composition of the manure was incomplete, and its N contribution in particular remains unclear.

Interest in extending the research findings seems to be lacking, and there does not appear to be any extension service that will take the findings to the farmer. The contrast between the extension of knowledge inherent in conducting projects on a farmer's fields and the lack of such extension in trials conducted within the confines of experimental stations poses a challenge for developing extension/research activities despite travel limitations for farmers.

Application of Research:

This project is part of a larger effort to determine what balance among leguminous crops, inorganic fertilizer, and manure is sustainable in dryland agriculture. The work produced basic information that may prove useful to wheat and chickpea producers. Further research may confirm that--in areas with low and uncertain rainfall--applying locally available, low-cost farmyard manure is a cost-effective investment as compared with inorganic fertilizers. Additional soil improvements might address soil biological activity, nutrient exchange capacity, water balance, organic matter content, the structure of the soil, and the efficiency of mineral fertilizers.

The results obtained using inorganic fertilizer to supply N and P resulted in increased crop profitability with dryland farming. These results are similar to those obtained by others. The application of these observations would significantly change the economic well-being of farmers and would likely result in decreased soil erosion as well (the increased crop growth would result in greater protection of the soil surface from the erosive effects of rain).

Future Support Needs:

The researchers intend to continue and expand this research. Parameters affecting nutrient availability and fertility/water relationships require further study. The researchers will undertake additional field trials before advising farmers to invest their scarce resources in this promising method of improving soil fertility.

The multiple N sources under study in this project (inorganic fertilizer, in situ fixed N, and animal wastes) will require experimental studies undertaken over several seasons to determine the economically optimum crop production/fertility system.

Extension programs related to N/P management under dryland conditions need to be developed. A major yield increase and reduction in soil erosion could be obtained as a result of such programs.

BOSTID PROJECT SUMMARY
GRANT #23

Title: Control Strategies for *Maydis* Leaf Blight of Maize

Investigator(s): Dr. Shabeer Ahmad
North West Frontier Province Agricultural University, Peshawar

Funds Awarded: $24,100 **Funds Spent:** $28,817*

Grant Period: 6/29/92-5/31/92

Project Objectives:

Maize is an important cereal crop of the North West Frontier Province. Because it is planted on marginal land, maize suffers many stresses, particularly *Maydis* leaf blight, which reduces yields by more than 50%. The overall objective of this project was to monitor the incidence and severity of *Maydis* leaf blight and assess losses in yield, screen maize germplasm for sources of resistance, and devise management schemes for controlling the disease. The specific objectives of this study were as follows:

1. To develop an integrated control model for *Maydis* leaf blight of maize in North West Frontier Province.
2. To identify the sources of resistance to *Maydis* leaf blight of maize (out of the local and exotic germplasm).

Project Status:

The above objectives were completed.

Accomplishments:

The investigators on this project are conscientious, and valuable information has been acquired with minimal funding. The researchers have been successful in outlining the terms and timing of a plan of integrated pest management to dampen the effect of southern leaf blight (*Maydis* species) on maize yields. A potentially important discovery was apparent evidence of a synergistic effect between certain genotypes and certain fungicide treatments; employing both components enhanced productivity beyond the simple addition of increases from the individual components.

Publications:

The following paper has been prepared for publication: "Synergistic Effect of Cultivar Type and Fungicide on Southern Leaf Blight and Yield in Corn."

Collaboration:

This project was visited regularly by group advisors. The following grantee visit was made: Dr. Shabeer Ahmad attended the Dryland Agriculture Institute Workshop at West Texas A&M University, Canyon, Texas (June 6-July 1, 1994), and then the Department of Plant Pathology (Dr. Charles A. Martinson), Iowa State University, Ames (July 2-9, 1994).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Advance American Technologies computer 486/66

* This amount may be adjusted pending verification of the final expenditure report.

Problems:

Initial concerns with the experimental design were rectified.

Unusually warm weather in 1992 curbed development of southern corn blight in the test plots, thereby precluding collection of a valuable set of data.

Although collaboration among the researchers was excellent, interest in extending the work to farmers was lacking.

Application of Research:

The research was well done and could be helpful to farmers if they have the opportunity to hear about the findings. Southern leaf blight can be a devastating disease. Taking advantage of the interaction between cultivars and fungicides will allow improved productivity at lower cost.

Future Support Needs:

Generally, results from field research done in one year only are not acceptable, although in this case the results were strengthened through use of multiple locations. The major expense of this research was in setting it up; maintaining field trials until a sufficient time series of data is generated could greatly increase the robustness of the findings.

The short duration of this program did not allow researchers to identify existing cultivars that meet all the criteria expected by local farmers.

It is important to increase the research attention paid to testing resistance of cultivars before they are released to farmers. Additional screening of local germplasm also seems warranted. In the fields are some plants with more tolerance; these should be collected and tested.

The levels of residual inocula in the fields are probably extremely high. For example, crop residues (used as fuel) are left in the fields over winter. Research on the effects of improved field management could be a major step in reducing the intermittent devastation caused by *Maydis*.

Continued development of more cost-effective fungicide treatments and efforts to find more resistant cultivars are important for maize growers in Pakistan.

Other constraints for maize production, such as lack of weed control, require that a comprehensive program on maize management be developed and demonstrated to growers.

Finally, it is imperative to maintain the close in-country research collaboration that has developed during this program, as this links research in field pathology with an outstanding maize breeding program.

BOSTID PROJECT SUMMARY
GRANT #25

Title: Selection of Cotton Varieties Tolerant to Salinity

Investigator(s): Dr. Akhtar Nawaz Khan
Faculty of Agriculture, Gomal University, Dera Ismail Khan

Funds Awarded: $24,700 **Funds Spent:** $25,199*

Grant Period: 6/10/92-5/31/94

Project Objectives:

Identification of varieties of cotton tolerant to moderate or high salinity would have great significance for agriculture in Pakistan. The overall objective of this project was to screen indigenous and novel cotton varieties for their tolerance to salinity and application to agricultural systems in Pakistan. The specific objectives were as follows:

1. To establish appropriate screening procedures for salt tolerance in cotton.
2. To identify salt-tolerant varieties of cotton from local and international cultivars.
3. To evaluate whether changes in K+:Na+ ratios contribute to salt tolerance in cotton.

Project Status:

The above objectives have been addressed, but the project did not include international germplasm.

Accomplishments:

The research demonstrated that salinity affects plant growth differentially depending on the salt tolerance of the cultivar. The field evaluation of the effect of salinity on the yield of cotton was important, and it is significant that the variety Rehmani was superior in salt tolerance under all test conditions.

Publications:

The following paper has been prepared for publication: "Selection of Cotton Varieties Tolerant to Salinity."

Collaboration:

This project was visited regularly by group advisors.

Interaction with other Pakistani researchers working on salt tolerance is recommended.

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Buck Scientific, Inc. flame photometer with filter
- Buck Scientific, Inc. air compressors (2)

Problems:

The project encountered the following problems:

- Updating of the hydroponic methodologies created difficulty in correlating data from earlier studies; these were apparently handled satisfactorily.
- Delay in delivery of a flame photometer slowed mineral analyses; time permitted screening only selected genotypes for K-Na content correlations.

* This amount may be adjusted pending verification of the final expenditure report.

- Small-scale heterogeneity of field plots necessitated redesigning replication blocks.
- As noted, the investigator was not successful in acquiring international germplasm for screening.

Application of Research:

The researchers concluded that measurements of shoot growth during the seedling stage correlate well with cotton yields in experiments evaluating the impact of salt stress. This finding could lead to a more rapid screening of genotypes for salt tolerance. To the extent rapid screening leads to genotypes with improved salt tolerance, this work will have a major impact on cotton production in saline areas.

Future Support Needs:

The team needs to conduct 1-2 more years of field evaluation before recommendations can be offered to growers. The next series of field trials would select the most promising cultivars and compare them with those currently used. Additional screening of other germplasm using methodologies developed in this project is also planned.

BOSTID PROJECT SUMMARY
GRANT #26

Title: Manipulation of Dera Ghazi Khan Rangeland to Improve the Productivity of Local Livestock

Investigator(s): Dr. M. Fatah Ullah Khan
Animal Sciences Institute, National Agricultural Research Centre, Islamabad

Funds Awarded: $26,600 **Funds Spent:** $30,508*

Grant Period: 6/21/92-5/31/94

Project Objectives:

The primary livestock species of Dera Ghazi Khan are cattle, sheep, goats, and camels. The majority of feed for these livestock is derived from the rangelands of the region. The overall objective of this project was to increase livestock production by establishing principles for range improvement and plans for sustainable range management. The specific objectives were as follows:

1. To characterize the range vegetation of Rakh Choti Delana for species, quantity, and nutritional value as affected by season and environmental conditions.
2. To compare the effects of protection and reseeding on forage production.

Project Status:

Although hampered by drought and inadequate time to measure more than broad trends, the project achieved its objectives of reseeding depleted rangeland and evaluating native vegetation.

Accomplishments:

This project represents an important step in documenting the gains that can be achieved by reseeding degraded rangelands. The researchers went about the project in a scientifically sound manner and were successful in reclaiming the arid land during the first year. In fact, the contrast between reclaimed and adjacent land was spectacular, with a ten-fold increase in fodder production. This research demonstrated that reseeding can be an important intervention in the improvement of rangelands such as that at Thatta Leghari: it improves forage production many-fold and increases livestock productivity. In the second year there was a drought, which left the project without data. Data collection continues on forage production and animal weight change.

This study yielded much-needed information on matching of local plant and animal resources to provide sustainable livestock production on arid rangeland. It could serve as a model for the Thatta Leghari area.

Publications:

The following paper has been prepared for publication: "Manipulation of a Highly Degraded Rangeland To Improve the Production of Forage and Livestock." Once more seasons of data have been analyzed, the group will submit this paper for publication in a referred journal, such as the *Journal of Range Management* or *Journal of Arid Environments*, as well as in Pakistani journals.

Collaboration:

This project was visited regularly by group advisors. Because of this project's perceived importance, BOSTID advisors spent a great deal of time supporting its literature (of which there is little) and data needs. In addition, the BOSTID program awarded the principal investigator a non-project-funded workshop and grantee visit to the United States: Dr. M. Fatah Ullah Khan visited the Dryland Agriculture Institute Workshop at West Texas A&M University, Canyon, Texas (June 6-July 1, 1994),

* This amount may be adjusted pending verification of the final expenditure report.

and then the U.S. Department of Agriculture's Jornada Experimental Range (Dr. Dean M. Anderson), Las Cruces, New Mexico (July 2-9, 1994).

Major Equipment Received:

Equipment items valued at more than $1000 include:

- Advance American Technologies computer 486/66

Problems:

Two years is an inadequate period in which to accumulate the data needed to implement management strategies. This is particularly true when there is a drought, as occurred during this project.

Analyses were hampered by incorrect entry and formatting of the data. This problem has been corrected.

Application of Research:

This research should have an impact on the overstocked arid rangelands of Pakistan. It provides an excellent example of early success in reseeding of rangeland. The application is likely to be important in the area, provided that the initial vegetation can be sustained over a longer term. The important data collection continues on forage production and animal weight change.

Future Support Needs:

The extremely dry environments of this region present great challenges and risks to scientists and land users that can be met only by continued research and its application within an appropriate resource management approach. Reviewers felt the project was on a "scientifically correct pathway" that is essential to rehabilitation of degraded natural plant communities, and that increased demands for products from these rangelands will most certainly dictate the reestablishment of plant species.

This type of research is completely dependent upon natural precipitation and thus seasonal influences. Monitoring the management system over wet and dry years is essential to determine the impact of both above and below average precipitation on the practical value of reseeding for productivity enhancement. The group plans to continue the trials, and round out the research with several more seasons of data. Now that baseline data are available on growth throughout the year, the design may be restructured to focus on end-of-season plant and animal data as a cost-saving measure.

Also desirable would be a socioeconomic evaluation to ensure implementation of results at a practical level. It is women, for the most part, who tend the livestock in this area; therefore, extension efforts should be focused on them regarding principals of grazing management, especially when successful reseeding offers substantial financial return. Evaluation of economic viability should also be conducted before wide-scale reseeding efforts are contemplated.

BOSTID PROJECT SUMMARY
GRANT #27

Title: Development and Transfer of Farming Systems for the Rod-Kohi Area

Investigator(s): Dr. Hamid Ullah Khan
Faculty of Agriculture, Gomal University, Dera Ismail Khan

Funds Awarded: $24,000 **Funds Spent:** $31,102*

Grant Period: 6/10/92-5/31/94

Project Objectives:

The Rod-Kohi (hill torrent/flood irrigation) agricultural system being practiced in the Daman area of Dera Ismail Khan is a unique traditional system. Flood water stored in the soil prior to the hot, rainless growing season is the only source of water for the crop. Traditional (nonimproved) crop varieties and obsolete farming methods are still being used. Rangelands have been overgrazed, and the sustainability of this system is threatened. The overall objective of this project was to test and introduce improved germplasm and appropriate farming practices in order to increase the sustainability of farming systems and the economic productivity of farms. The specific objectives were as follows:

1. To collect local resource data on land capability, irrigation availability, and crop and fodder germplasm.
2. To improve soil and irrigation management systems through modification of existing structures.
3. To identify high-yield and good-quality crops.
4. To test and verify high-return technologies suitable for farmers of the Rod-Kohi area.
5. To introduce improved packages of production technology to replace the traditional cropping patterns.

Project Status:

The above objectives have been accomplished to the extent possible. Data must be collected over more seasons. Testing of new varieties is usually an unending task because of the diversity of available varieties--and continuous production of new varieties. Few of the new varieties of chickpea and wheat were tested, so more work can be undertaken here.

Accomplishments:

In this study, the researchers shifted from their traditional interests (plant sciences and botany) into farmer-oriented crop production systems, including the management of soil, water, and crops. Their efforts included making farmers aware of the utility of prior research, as well as explaining the objectives and results of the project. The researchers' efforts to study and demonstrate the effects of tillage provided means and opportunities to interact not only with the farmers on whose land the research was conducted, but also with other farmers in villages near the project. The farmers benefitted from the direct knowledge transfer and also became aware of how to take part in government programs for farmers that provide assistance in obtaining new seed varieties, funding for farming operations, and other farm assistance.

The research was designed to use sustainable tillage methods to trap greater amounts of water or to increase the rooting depth of crops, thereby increasing the amount of stored water available to the crop. The results indicate that tilling of fields before flooding could, without extra resources,

* This amount may be adjusted pending verification of the final expenditure report.

substantially increase yields through increased water retention. In addition, the data were valuable for comparing local and improved varieties of wheat and chickpea.

Publications:

The following paper has been prepared for publication: "Pre-flooding Tillage Influences on Wheat and Chickpea Production in a Semi-arid Climate of Pakistan."

Award Received:

This project received the Award for Personal Commitment to Research.

The leader of this project showed outstanding personal commitment to the research and the local farming community. The research team has dedicated enormous time, creativity, and personal resources to developing an impressive collaboration with the Rod-Kohi farmers.

Collaboration:

This project was visited regularly by group advisors.

The following grantee visit was made: Dr. Hamid Ullah Khan to the Department of Soil and Environmental Sciences (Dr. James Oster), University of California, Riverside; the International Center for Arid and Semiarid Land Studies (Dr. Harold Dregne) Texas Tech University, Lubbock; the U.S. Department of Agriculture Conservation and Production Research Laboratory (Dr. B.A. Stewart), Bushland, Texas; Walnut Gulch Watershed (Dr. Ken Renard), Tucson, Arizona; and the University of California at Davis (August 12-28, 1993).

In addition, Dr. Hamid Ullah Khan attended the Dryland Agriculture Institute Workshop at West Texas A&M University, Canyon, Texas (June 6-July 1, 1994).

There was also good collaboration with BOSTID Project #21 (Dr. Bhatti), which should be encouraged and continued.

Major Equipment Received:

No equipment was purchased for this project.

Problems:

Flooding during the experimental period was highly erratic. This severely limited the crops, which are totally dependent on that water:

- In one season, the flood water was diverted by others to different land.
- In another season, the rains were extremely late.

Application of Research:

The researchers are teaching local farmers what can be accomplished with different agricultural practices. These intense extension efforts have generated a lot of interest among the farming community, and several farmers have already adjusted their field management to fit the recommendations.

Future Support Needs:

The current data cover only two partial cropping years, and thus lack the repetition over different seasons needed to yield robust recommendations. The research team intends to continue the research and expand it to include a broader range of field sites and variables.

Particular areas of interest would be characterization of the nitrogen and phosphorus status of recent alluvial sediments farmed in the Rod-Kohi areas. Other, more expansive research studies could include the impacts of improved cropping systems on the social/economic infrastructure; these range from impacts on family and the cultural structure of the community to impacts on the joint governance and sustainability of the Rod-Kohi irrigation system.

There needs to be future collaboration with a soil scientist who will characterize the physical and chemical properties of soil in this area.