BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAK-532	2. SUBJECT CLASSIFICATION (695) AA50-0000-G512

3. TITLE AND SUBTITLE (240) Status of agronomic research in Bolivia: Saavedra, San Benito, Toralapa, and Chinoli

4. PERSONAL AUTHORS (100)

Smith, R.L.

5. CORPORATE AUTHORS (101)

Consortium for Int. Development

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1976		

9. REFERENCE ORGANIZATION (130) CID

10. SUPPLEMENTARY NOTES (500)

(In working paper no. 003/76)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Agricultural research
Evaluation
Agricultural development
Program evaluation
Bolivia
Program management
~~Agricultural economics~~
~~Publications~~

13. PROJECT NUMBER (150) 5110451

14. CONTRACT NO.(140)

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

AID

PN-AAK-532 20187

CONSORTIUM FOR INTERNATIONAL DEVELOPMENT

CID

Colorado State University
Oregon State University
Texas Tech. University
University of California
University of Arizona
Utah State University

Working Paper No.
Documento De Trabajo No.

LA PAZ, BOLIVIA

Preliminary: For Discussion Only

003/76

STATUS OF AGRONOMIC RESEARCH IN BOLIVIA: SAAVEDRA, SAN BENITO, TORALAPA, AND CHINOLI

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May 14, 1976

STATUS OF AGRONOMIC RESEARCH IN BOLIVIA:

SAAVEDRA, SAN BENITO, TORALAPA, AND CHINOLI

Introduction

This report constitutes an appraisal by CID technicians of the Status of Agricultural Research on the Experiment Stations included under the CID Contract No. GOB/AID-511-92. The stations included are Saavedra, Toralapa, San Benito, and Chinoli. The report focuses on agronomic research with only peripheral consideration of animal and fruit research. The assessment serves two basic purposes: (1) to establish a "benchmark" of current research programs and to suggest improvements based on the initial months of the contract, and (2) to provide a basis for redirection in long-term program emphasis, including changes in research policy. This assessment also provides general guidelines for expenditure of loan funds available for improving physical facilities and upgrading technical competence. This is an independent CID appraisal in the sense that the Ministry of Agriculture has not provided inputs to this point. This system was followed at their suggestion in order to accord the greatest freedom to the CID assessment.

This report is organized in the following way: section one presents a philosophy of research with particular attention to the Bolivian situation along with some general recommendations; section two discusses

the station locations; section three describes the problems related to physical facilities; section four presents an overview of general problems and suggestions for program development; section five gives our specific suggestions and recommendations for the programs at each station; section six discusses the personnel and training program; section seven focuses on the problems of budgeting and finances; section eight presents recommendations for reporting research information; section nine contains a summarization of our recommendations.

Philosophy of Research

The primary purpose of applied agricultural research is to discover new knowledge and to adapt new technology to commercial agriculture conditions. Agriculture experiment stations must be designed with this philosophy in mind. The physical facilities and financial and human resources must be organized to expedite the generation of agricultural knowledge and the efficient dissemination thereof. There should be nothing to hinder this primary purpose. Any research endeavor must, however, function within acknowledged limits. Resources are always limited, and they must be devoted to solving the most pressing problems and to support research in those areas of highest priority. Only as more resources become available can research programs be expanded.

Achievement of these goals requires a high level of competence among research and extension leaders. They must be properly trained in order

to assist farmers in achieving the yield potentials available from intensive agricultural production methods.

Bolivian Stituation and General Recommendations

For the successful continuation of agricultural research in Bolivia, most of this research competence must be developed within the country. This will require a constant supply of adequately trained technicians, research project leaders and extension agents. Many countries have experienced success through a close association of Agriculture Experiment Stations with Agricultural Colleges within the University system. Agricultural teaching and research programs within the Bolivian University system should be encouraged through scholarships and other enducements to develop undergraduate and masters level programs specifically aimed at filling the agricultural science needs of the nation.

Agricultural research should be given economic independence free of outside pressures. Experiment Stations cannot effectively generate new knowledge if they have a permanent preocupation to produce and sell commercial crops as a source of operating revenue. The costs of research should be the responsibility of the general society in order to give the investigative process an opportunity to discover knowledge for the benefit of that society. The "pay-offs" in the United States and other developed countries from agricultural research have been highly significant and have resulted in better food at lower costs.

The efficiency of the research process is in a large measure a function of the number of processes assigned to the research stations. Thus an agronomic research system is most effective when limited to the generation of knowledge concerning agronomic interrelationships. The management and development of a seed multiplication capability must be an independent effort which incorporates the capability of both government and private institutions. Combining the seed multiplication effort with the research program will always dilute the research program since competition for money and physical resources will develop.

The size of research stations, therefore, should be limited to that necessary for research purposes. For agronomic programs 30 to 40 hectares is generally sufficient. Regional trials needed to test climatic and variety differences and trials of actual on-farm responses can be located off the station. Where animal and fruit research programs are involved,larger areas will be needed. However, this report focuses only on agronomic research which is consistent with the orientation of the CID contract.

Within the next few years, the Ministry will develop several "regional agricultural service centers" to provide coordination of research, extension, agricultural credit, and other farmer-oriented services. The center in each region should be the hub of all activities of development, demonstration, dissemination, and adoption of improved

technologies and management practices. Since research programs will be required to provide the basic data and pool of knowledge for these related activities, the Agricultural Experiment Station should be the basis or framework around which the service centers are built. The centers should not be built at locations such as Mizque, which is a long distance from an experiment station.

Overall, agricultural research in Bolivia lacks national direction and control. Individual stations and technicians are given excessive independence in conducting agronomic research. This independence is excessive in the sense that individual research projects are not given sufficient annual review and evaluation. Some lines of investigation continue year after year in spite of no evident progress. It is recommended that national control be exercised over all works conducted at the experiment stations. To be most effective, control should be exercised by the office of the National Director of Research and should include in-depth appraisals of the technical programs will before the start of each planting season. A board of technical experts, including the National Director, his CID counterpart, the National Director of Extension, his CID counterpart, and the Co-Directors of the stations should review each project of that station with the individual technicians annually in order to justify the proposed work, to coordinate inter-station research, and to initiate necessary changes and reforms. Such a procedure should lead to an efficient national research system.

Agricultural research cannot reach its full potential until the total system becomes effective.

A serious restraint in effective agricultural research in Bolivia is the current method of funding individual projects. Although projects and budgets are prepared and approved, there is no guarantee that money will be made available to the project leader on a timely basis. It has been argued that the factor that most restricts quality research is limited funds. As important as funds and other resources are, the single factor most restricting quality research is the lack of control over these limited resources. Therefore, it is essential that the funds necessary to run the total station operation be under the control of the station Director. He can then allocate to the project leader those funds required to conduct the individual research program.

Station Locations

The stations at San Benito and Toralapa are well located. The station at Chinoli probably could be better located but the arguments for moving it are not strong. More will be said later about the programs being carried out at these three stations.

The Station at Saavedra is not located for effective agronomic research in the Department of Santa Cruz and serious consideration should be given to the establishment of a small (30 to 40 hectares) experimental

farm closer to Santa Cruz. The possible advantages of such a move are:

a) A site with year round access.

b) A closer relationship with the University for field and classroom instruction could be established. (The University has acquired land close to Santa Cruz. A cooperative effort could be made for the establishment of a joint station).

c) Since the station would be within commuting distance of Santa Cruz extensive technician, housing would not be required.

d) Services for station personnel and families would be improved.

e) With the research committed only to agronomic problems, a smaller operating budget would be required.

f) More rapid communication and completion of administrative duties with the La Paz and Santa Cruz Ministry offices would be possible.

g) Availability of repair services for machinery, etc., would reduce down time.

Some concern has been expressed by Ministry personnel that any location farther south (closer to Santa Cruz) would not be representative of the Saavedra area with respect to climate. The weather records from 1951 to 1970 show there are some differences in precipitation, temperature and relative humidity, but these differences have been small as indicated in the following table:

Santa Cruz	1951 - 1970	Saavedra
24.6	Average temperature (C°)	23.8
1129.3	Average rainfall (mm)	1205.9
67	Relative humidity (%)	65

The initial expense for the establishment of a new station would be less than that required to restore or construct new physical facilities at Saavedra. The greatest expense would likely be in the development of an irrigation system.

Since a large part of the land holding at Saavedra is currently devoted to the animal program and for seed production, it is recommended that the station be redesigned for these programs and placed under independent management. With the current large size of the station these programs would be compatible.

There are organizational problems that have been encountered in Santa Cruz in both the operation of the research program at Saavedra and the overall extension program that must be corrected before significant progress can be made in fullfilling the objectives of the CID contract. There are no facilities for technician's families at Saavedra. Even if facilities were built,it would be impossible to get families to live there as there are not adequate schools in the surrounding towns. At the present time the Ministry furnishes salaries for the MINAG technicians but does not provide a budget for conducting research. This money comes from Santa Cruz Obras Públicas. They have been slow in allocating the

money for those projects they have approved and have taken the position of approving programs on a project by project basis. By this system they essentially control the program scope when this responsibility should be in the hands of the technical specialists. The research technicians receive no support from the extension agents who are currently devoting full time to the Banco Agrícola. If the situation cannot be satisfactorily corrected, we recommend that our efforts and resources be withdrawn and a more consolidated effort be made in Cochabamba.

Physical Facilities

Physical facilities at the four experiment stations are woefully inadequate. The Ministry, with CID input, is preparing a detailed list of facility improvements and additions that will be financed by a loan which is complementary to the CID contract. This will be presented as a separate document, but it is felt that the major deficiencies and our recommendations should be documented here.

One of the more serious deficiencies is the lack of electricity at the stations. At the present time only Saavedra and San Benito have electrical power lines while the other stations must operate on generators. Even if this source were reliable, it would be impossible to operate modern laboratories and shops on such electricity. It will be impossible to develop the "regional center" concept in the absence of

electricity. Electrification of the stations will improve not only working and living conditions, but will produce a higher morale among station workers. It is accepted that much of the "outreach" program carried on by the extension personnel will require that they go into conditions where portable generators will be used, but the "centers" must be as efficient as possible.

All existing stations will require new or modernized potable water systems. In Santa Cruz and at San Benito irrigation will be required, and new wells will need to be drilled. New irrigation systems or upgrading of the current ones will be required.

Since the "center" must be easily accessible, the road into the Toralapa station will need to be improved and, if Saavedra is to be used as the Experiment Station in Santa Cruz, the entrance road will need to be made into an all-season road.

Research requires the scientist to be up-to-date on activities in his field. Since the stations are somewhat removed from the University libraries, a small technical library must be established at each station and stocked with pertinent books and journals.

One of the most important aspects of agronomic research is maintaining viable seed stock from year to year. This is especially true of oil seed crops especially in a hot, humid climate like Santa Cruz. Although it will require a more specialized storage facility in Santa Cruz, adequate facilities must be built at each station.

The buildings, such as laboratories, dormitories, housing, offices, storage sheds, machine shops, classrooms, and lecture facilities and libraries will either have to be built or updated at each station. This includes the buildings and support facilities for the "center" and not just those required for the research activities.

Each station should have access to modern biological and chemical laboratories where the research workers, extension workers and farmers can obtain soil and plant analysis. There are such laboratories in Santa Cruz (run by the British Mission), in La Paz (run by MACA), and at the University in Cochabamba.

There should be a careful evaluation of these laboratories and a determination made as to whether they can satisfy the needs for the country for soil and plant analysis before construction commences on separate laboratory facilities at the research stations. Money and resources invested in improving laboratories at the Agricultural Universities and those existing elsewhere would have immediate and long-term returns, and possible cost considerably less money than required to build,equip, staff and maintain laboratories at the stations.

If the Ministry personnel feels they must have laboratories at the agricultural experiment stations, they should time phase these constructions rather than building all of them at once. The first laboratory should be built in Cochabamba. The British Mission laboratory in Santa

Cruz and the MACA soils laboration in La Paz should handle the analysis while the Cochabamba laboratory is being built and equipped. By the time this first one is fully operative, considerable information will have been gathered to guide the Ministry in their decision on other laboratories.

Each station should be self-sufficient in light machinery and equipment maintenance. This will require a well-equipped shop run by trained technicians.

The basic farming equipment necessary to prepare the land and maintain and harvest the crops is either lacking or in poor condition at every station. This will require a considerable initial expenditure to upgrade this equipment. However, if the farm size is kept to that required only for agronomic research, the initial outlay will be much less than if current commercial farming practices are continued. With a small sized station, the size of the machinery, such as tractors, can be much smaller and the physical depreciation on the equipment will also be markedly reduced.

Experimental plots are usually of a size that much of the labor beyond seed bed preparation is done by hand. However, each crop requires specialized equipment such as an individual head thresher for cereal breeding or small plot threshers of corn, soybeans, rice, peanuts, sorghum, etc. Seed cleaning equipment that is specialized for the type of crops grown at each location will also be required.

Program Development

Program development at all stations suffers from four general deficiencies: (1) program focus, (2) ineffective use of the extension program, (3) insufficient research on problems of farm management and cultural practices, and (4) research not designed for economic interpretation.

Program Focus

The breadth of the research program is much too great and does not have sufficient focus. Given the human and money resource restrictions that exist, the number of crops researched and experiments that are established are much too numerous to be effective. There are few if any long-range plans and the number of programs tend to grow and expand each year because the technicians are given too much independence in research selection. The smaller the research resource base, the more care and evaluation that must be put into defining the research program.

It is evident from the following table that the program is extended far beyond the capability of current human and financial resources. The picture is even more bleak than illustrated here because many of the experiments which appear in this tabulation as a single entry are, in reality, regional trials (e.g. variety testing, fertilizer rate studies, variety-fertilizer interactions) where the same experiment is duplicated in many different locations.

Table 1. Summary of the number of experiments planned for 1975-76 by commodity for four experimental stations:

	Saavedra	San Benito	Toralapa	Chinoli	Total
Potatoes	2		25	11	38
Vegetables	7				7
Corn	7				7
Wheat		18		11	29
Rice	7				7
Barley, Oats & other cereals	9			8	17
Sorghum	2				2
Peanuts & other oil seed	5				5
Deciduous fruit	2	20			22
Forages	8			7	15
Animal	6			9	15
TOTAL	53	47	25	46	171
Number of technicians	10	8	6	5	29

Research programs at the various stations may be brought into sharper focus in several ways. We recommend that the following scheme be followed: (1) At each station one to three crops should be identified as those where the greatest "pay-off" to the farmer and to Bolivia will result from the research efforts expended. This means that most of the research program at that station will be aimed at solving those problems restricting production of these crops. As specific problems are solved, as more resources become available, or as situations change the crop priority can change. The crops we suggest to receive priority at this time are potatoes, forages and broadbeans at Toralapa; cereals, fruits and vegetables at San Benito; and corn, rice and oil crops at Saavedra. With this system, the demonstration programs and regional trials at Chinoli will be directed from other stations. Our arguments for selecting these crops will be developed in a later Section, "The Station Research Program." (2) A second method of sharpening research focus is to establish goals, both short and long range, and to evaluate all proposed research in relation to these goals. The evaluation must be based on immediate and eventual benefit to the farmer and not just on the collection of scientific data. Some programs may simply have to be delayed in favor of those programs where the potential "pay-off" is greater. We have done this for the individual stations in the Section on the research programs.

The Role of Extension

A second serious deficiency in the overall research programs is their ineffectiveness in expediting the flow of agronomic information and technology needed by the farmer. For example, very few significant new variety selections have been adopted by the campesinos during the last 15 years even though the research program has demonstrated that some of these varieties produce several times more than the native varieties or the varieties currently used. Furthermore, the investigation of other agronomic responses to new technologies (such as response to fertilizer, weed control, seeding density, etc.) has not led to as much campesino adoption as would be expected given the significant responses demonstrated at the stations.

The Extension Service, particularly the Extension agents, should play a more significant role in the research program. Since one of their principal roles is to extend the research technology to the farmer, they must not only be knowledgeable about the research being carried out at each station, but they must give some guidance and direction in the development of this research program. They should constantly bring back to the research staff those agronomic and management problems they see on the farms. They should serve as motivators to insure research data publication where it can be of use to them and to the farmers.

In particular, Extension should be largely responsible for farmer field demonstrations. The research technician could be involved in the

design, but need not be involved in the establishment, maintenance or data collection from the demonstration. An agent who is skillful in putting out demonstrations and in utilizing them for community-wide field days will be most productive.

Cooperative publication between Extension and Research workers is highly desirable. These will not only include the circulars and leaflets that are essential in extending the research program, but could also include bulletins and journal articles.

Farm Management, Cultural and Agronomic Practices

The problem here is two fold. First, research is usually conducted at a technological level foreign to the farmer. More emphasis should be put on adapting existing technology to fit the "real life" system of the campesino. Too often we attempt to jump directly from a low technological level to the highly sophisticated level used in the developed countries. Much can be accomplished by first introducing and developing an intermediate technological level. Second, the farmer's current cultural and agronomic practices can be improved. Cultural practices include: (1) seedbed preparation, (2) seeding rates, (3) soil moisture management, (4) date of planting, (5) date of harvest, and others. The agronomic practices include: (1) the use of fertilizers, (2) irrigation, (3) weed control, (4) insect control, (5) consorciated plantings, (6) sequential cropping, (7) rotations, and others. Considerable

information has been generated by past experimental trials on improving these practices. Unfortunately, few of these improvements have been incorporated into farmer practices.

Farm equipment, tools and power. The current use of specific pieces of farm equipment or tools and the methods of farming may be the result of nothing more than custom and tradition. In other areas of the developing world, there has been considerable experimental work on developing an intermediate technological level of farm tools, equipment and power. Experimental work here should take a careful look at what might be done to improve on-farm power sources and the efficiency of existing technology. An agricultural engineer should be obtained, perhaps initially as a short-term consultant, to provide program direction in this area.

Irrigation research. Considerable benefit will be realized from research on irrigation practices and techniques. The Santa Cruz area has potential for winter season (dry season) cropping under irrigation. In Cochabamba, limited irrigation is practiced along the rivers of the valleys, and some wells have been drilled for irrigation, but there should be more direction and guidance from the stations. The upper valley of Cochabamba seems to have some potential for deciduous fruit, and, possibly, vegetable production. The prolonged dry season precludes

these crops, but irrigation might make them profitable. An irrigation specialist should be obtained, perhaps as a short-term consultant, to evaluate the potential. An irrigation technician, either Bolivian or CID specialist, should be added to the program as soon as possible.

Fertilizer trials. Considerable effort has been given to a wide variety of different fertilizer trials. However, the complexity of the experimental design necessary to test the effects of fertilizer levels and interactions makes interpretation of the date extremely difficult and possible misleading. Many of the fertilizer trials conducted during the past few decades have been of this complex type with three fertilizer elements applied at various rates and in all combinations.

The fundamental need for using a soil test determination to assist in fertilizer recommendations must be recognized by both the researcher and the extension worker. All fertilizer experiments should have this as a primary goal. As data are accumulated on crop yield to added fertilizer, a correlation analysis will show what the soil analysis "critical value" for that element will be. When this is known, the analysis from a well-taken soil sample can remove 90-95% of the guess work as to whether a particular crop will respond to that added fertilizer. This means that all fertilizer rate studies must be coordinated for the different stations. A soil fertility assay sample should be taken as a prerequisite for designing and conducting all fertilizer studies.

Another problem is that no data has been kept on the amount or kind of fertilizer applied to the various fields at the stations. New experiments are being located on the fields with no regard for the fertilizer carryover. In our opinion, this has confounded the fertility experimental results and make them suspect. A detailed soil analysis of the research plots or fields on each station must be made and maps prepared to guide research studies over the long range.

At the present time, there is no soils technician at any of the four stations. Each station should have this capability, but initially one technician should be given supervisory responsibility for soils related problems at all stations.

Insect, disease and weed control. It is accepted by agronomic researchers in Bolivia that failure to control insect, disease and weed problems might reduce crop yields. It is not fully appreciated, however, that failure to control these problems may invalidate a research trial or, even more insidious, lead to completely erroneous conclusions. These variables must be controlled if reliable research results are to be realized.

Each crop has specific disease and insect problems, and each geographic area is somewhat unique in the types of weeds encountered. At this time, it is impossible to fully staff each station with technicians trained in all areas of insect, disease and weed control for all crops.

This expertise should be developed among agricultural students as rapidly as possible. Some of this expertise can be supplied initially either through Bolivian technicians, CID technicians or short-term consultants. Training new technicians on the job by consultsnts could be a possibility. Available technical expertise in insect, disease and weed problems must initially serve the several experiment stations. The long range goals should be to develop this type of expertise within the country and eventually to fully staff each station.

Economic Interpretation of Management Systems

An agricultural economist should also study the following areas:

1. Compare traditional versus "new" production systems;
2. Investigate the socio-economic impact of new technology in production of the various crops;
3. Conduct a survey of farm size-labor requirements, production costs, etc.,with the idea of using this information to direct the formation of "packages" of varying technological input which could or should be readily adopted;
4. Assist in agronomic experimental design;
5. Study marketing problems and make demand projections for crops which are given agronomic emphasis.

The Station Research Program

The research program at each station should be unique in the sense that the problems specific to the region serviced by the station should have research priority. Thus, there should be little or no duplication of basic research on any crop among stations although there will, of necessity, be experiments to test and transfer the technology and techniques throughout the country where any particular crop is grown.

Since the individual stations have unique crop research priorities, the suggested station program will be considered separately. However, we have identified the following general agronomic constraints to production in the region: (1) adapted varieties, (2) weeds, (3) insects, (4) diseases, (5) soil fertility, and (6) cultural practices (density of stand, time of planting, seedbed preparation, soil moisture control, etc.)

Saavedra

The size of the Department of Santa Cruz and the number of climatic zones it encompasses will always dictate that a number of crops and agricultural enterprises be economically important. When cotton and sugar cane are excluded from the CID program, the two remaining crops of current economic importance in the Santa Cruz area are corn and rice. The crops of lesser importance are soybeans and sorghum. One industry

that will likely increase significantly in the next few years is livestock production--beef and dairy cattle, poultry, and swine. The British Mission have recently contracted to supply expertise in beef and dairy cattle production including pasture and forage production. If this industry expands as projected, there will be a great demand for animal grains. The major research emphasis at Saavedra should be to help the farmers meet this demand for feed grain, particularly with corn and grain sorghum.

Corn and sorghum. Corn reportedly occupies over 50,000 hectares in Santa Cruz and is grown largely on small farms. The average production is just over 1,000 kg/ha. The production of the improved varieties and strains at the station and in the regional trials is consistently over 5,000 kg/ha with quite a number of trials exceeding 8,000 kg/ha. The technician is well-trained in corn breeding and is using variety and breeding materials obtained from CIMMYT in Mexico and Pairumani in Cochabamba. The breeding and variety selection program should be continued but the major deterrent to increased production is lack of seed of the improved varieties and extremely poor extension program of getting the information to the farmers. More emphasis should be given to controlling the insect problems. Chemical weed control in trials has been effective and this should be demonstrated to the farmers.

The estimated area planted to grain sorghum in Santa Cruz is 400 hectares. Various hybrid introductions have proven well adapted for the Santa Cruz area. For instance, in the FAO - Abapo-Izozog project experimental yields ranged from 2,000 to 4,000 kg/ha. and the Saavedra station reports yields up to 6,000 kg/ha. Sorghum could become an important crop in the drier zones south and east of Santa Cruz where corn cannot be grown because of drougth. Competition from corn would likely limit the acceptance of sorghum in the higher rainfall belt north and west of Santa Cruz. At the present time, most of the sorghum grown is from expensive, imported hybrid seeds. A most serious drawback of hybrid varieties is that the hybrid seed must be produced new each year. Plants grown from the seed from hybrid plants do not produce more hybrid plants, but segregate into the parental lines. Open pollinated varieties breed true and produce the same variety year after year so the seed can be saved and planted. However, the yields are generally lower than from hybrid seed varieties. In the long run, it may be desirable to produce hybrid seed in Bolivia, but this will require expertise not now available. For the moment, the testing of the production potential for sorghum can be done much cheaper by using open pollinated varieties. This year, 1976-77, a number of these varieties can be brought in for testing. Sorghum is similar to corn in most agronomic responses and trials should be established to determine the response to fertilizer, density of stand, date of planting, weed and insect control, etc.

Rice. Rice also occupies a reported 50,000 hectares in Santa Cruz with all of it grown under upland conditions utilizing natural rainfall. The commercially available varieties are from the U. S. and Brazil and were developed at least 25 years ago. Most of the rice is produced on small farms with hand labor in newly cleared forest areas. However, an increasing amount is being produced on larger, mechanized farms. Based on the hectarage, this crop is equal to corn, but the high "pay-off" from rice research at this time does not appear as likely as for corn. The rice research program has shown progress by testing varieties introduced from a number of the rice centers throughout the world. We anticipate no immediate need for a breeding program. But the effectiveness of the variety testing program in Bolivia is limited by the lack of trained personnel. It is recommended that one or two technicians be sent for advanced training in rice production.

There is little evidence of a systematic and positive identification of rice diseases in the Santa Cruz area. The most frequently cited disease is rice blast (caused by the fungus *Pyricularia oryzae*). Other diseases noted in reports are *Helminthosporium* blight, and various seedling and root rots. There are undoubtedly others. At the present time, no technicians are trained in these diseases. This should be a specialty area of one of the technicians sent for training. In the meantime, a short-term consultant should be brought in to assist with these problems.

A survey in 1971 by Ing. Agr. F. Oscar Terán lists seven insects as major pests of rice in Santa Cruz. However, there are no technicians who have the training to deal with insect problems. It will be necessary to supply this expertise with short term consultants until technicians can be found here or trained.

Soil fertility trials were conducted before 1970 to determine the regional need for fertilizers on rice. These indicated a nitrogen deficiency on lands which had been cropped more two years without fertilizer. There are no reports on studies concerning the need for phosphorus or potassium. Simple fertilizer trials will need to be set up, initially varying only a single element in order to establish the "critical range" for these elements. When these are obtained, more elaborate studies can be run to examine interactions that likely occur.

There are a number of other cultural practices (seeding rates, time of planting, etc.) that have been researched at Saavedra. Results have demonstrated the potential for yield increases using these practices. As yet very few farmers have made any of these changes. This information must be taken to the farmers.

Soybeans. Of the oilseed crops currently grown at the Saavedra station (soybeans, peanuts, sunflower, and safflower), only soybeans appears to have sufficient promise for a significant research program. The hectareage has reportedly increased from 400 to over 8000 in the

last couple of years. This crop exhibits a wide range of adaptability to Bolivian production conditions and variety selections are being researched at the station. The program for 1976-77 should focus on two areas: (1) variety selection and an initiation of a breeding program, and (2) cultural practices.

1. Variety selection and breeding. The CID technician will give direction to this aspect of the program. A Bolivian technician should be sent for advanced training in this area while the CID technican is here. Since all of the varieties in use are introduced, a breeding program should produce new varieties better adapted to Bolivian conditions. This should result in greater yields. Eventually, a hybridization program can produce plants where the desirable characteristics from two or more parental types can be established in a new variety. Bolivia has a climate where it is possible to grow more than one crop per year, but the same variety is seldom grown during the two growing seasons. The breeding program will focus on developing varieties that can be grown during the winter season.

2. Cultural practices. Previous research on fertilizers, weed control, time of seeding, density of stand, etc., should be continued. Since the crop is relatively new to Bolivian farmers, considerable extension work will be required. The problems that develop on the farms will need to be brought to the station for subsequent research.

Toralapa

The crops of major importance in the Cochabamba area serviced by the Toralapa station are: (1) potatoes, (2) forages (barley, oats and legumes), and (3) broadbeans. Although there will likely be research trials at Toralapa on forages, the direction for this program should come from some other station that is specializing in forage research, such as Patacamaya. At the present time, there is no reach on broadbeans, but there are reasons to include this crop in experiments with potatoes.

Potatoes play an extremely important role in the economy and nutrition of the Bolivian and Andean region of South America. At present, Bolivia produces enough potatoes to satisfy her internal needs, but because yields are relatively low, this is done at considerable expense by occupying large quantities of good land that could be used for other crops. If the quality and quantity of potatoes were sufficient, Bolivia could become an exporter.

In order for Bolivia to reach this potential, it is essential that a potato breeding program be started, to go along with increased efforts in management and cultural practices.

The potato research program for 1976-77 should be organized into four categories: (1) plant breeding, (2) soil fertility and other cultural practices, (3) pest control, and (4) small farm technology. The potato research program at Chinoli should be designed and directed from Toralapa.

1. Potato breeding. This program should differ from that of past years in that an active breeding program should be initiated as well as a program of selection from varieties and lines now available. Part of this work can be started in the greenhouse in the winter of 1976. The specific objectives of the program should be: (a) yield trials with native and Holland varieties, and (b) breeding for nematode resistance, cold hardiness, and yield and quality. Currently, the direction for this breeding program can come from the International Potato Center in Perú. A Bolivian technician should be sent for Ph.D. training in plant breeding.

2. Soil fertility and other cultural practices. The soil fertility program should be reduced considerably and the focus changed to a calibration of diagnostic tests for soil fertility. Three year trials should be set up for potatoes where a single fertilizer element, such as phosphorus, can be varied in such a way that soil test phosphorus and yield correlation can be obtained. If enough fields low in phosphorus can be found, the experiment should be extended to include other crops, such as forages and broadbeans. As soon as time permits, experimental trials should be added that will allow one to obtain a similar soil test value for nitrogen and potassium for predicting fertilizer needs. The other cultural practices that should be researched are: (1) plant population, (2) planting date, and (3) seedbed preparation.

3. Pest control. Work on nematode control should be intensified. This should include: (1) studies on chemical pesticides for nematode control, (2) rotation as a means of control, and (3) the effects of mixed population of nematodes (*Nacobbus* sp. and *Heterodena* sp.) on potato production. A study on the identification of viruses in potatoes (usually associated with insect vectors) should be initiated. The efficiency of chemical herbicides on weed control should be continued.

4. Small farm technology. This area appears to have been neglected in the past. Several areas should be investigated:

a) Various crop combinations, such as potatoes and broadbeans.

b) Various systems of rotation utilizing potato, broadbeans and cereals.

c) Seedbed preparation as means of soil moisture management.

d) Economic evaluation of traditional versus "modern" technology in crop production.

San Benito

There are a number of crops that are grown in that portion of Cochabamba served by the San Benito Agricultural Experiment Station. These include: (1) cereals (wheat, barley, oats), (2) deciduous fruit (principally peaches), (3) numerous vegetables (broadbean, onions, tomatoes), and (4) corn. At the present time, research on the station

is confined to the cereals and deciduous fruits. Since the CID technicians have no expertise in dedicuous fruit culture, we will limit our discussion to the cereal program. (A consultant in deciduous fruit culture should be obtained to give guidance in this program). We will also need more time to assess the research needs related to selected vegetable production. However, we see excellent potentials for consortiated plantings research.

For 1976-77, however, the program should focus on three areas or categories: (1) barley, (2) cultural practices for cereals, and (3) wheat.

Barley plays a major role in the forage and livestock feed production area in Bolivia. Also, there is a considerable need for malting barley. Therefore, the emphasis in small grain research should be on barley and not on wheat. The wheat program of the past 20 years has produced some improved varieties and strains and research has demonstrated that the technology is known whereby wheat yields can be increased several folds. However, given the current situation, it is a waste of resources to continue to put a major research emphasis on wheat in the traditional areas. The program there should be one of limited breeding and variety testing and selection and more on demonstration and getting the farmers to use the varieties and cultural practices that are known to give the highest yields. The tremendous amount of time and effort

spent on evaluating lines and crosses from other countries should be reduced. The cooperative effort developed in the meeting in Brazil in 1974 should be strengthened.

The major effort in the wheat program should be in breeding, selecting and developing varieties for and studying conditions of the high rainfall areas such as Beni, Santa Cruz and northern La Paz, where wheat might be grown as a winter crop.

The triticale program should be discontinued. This crop is so new that the place in a cereal program is not determined. The claims of high yields and of a substitute for wheat have not been substantiated. While the current controversy exists, we see no place for triticale in the cereals program in Bolivia.

Chinoli

The major crops grown in the area serviced by the Chinoli Station are potatoes, wheat, forages, and quinua. The basic research for these crops should be located at other stations and Chinoli should serve as a regional demonstration station with no basic research responsibilites. The problems of the area, fertility, pest control, cultural practices should be researched at Chinoli, but the programs should be directed from the station given responsibility for that crop.

Personnel and Training

The following people have already been identified as candidates for advanced training:

1. Eng. Agr. Salaues, Santa Cruz, for training in rice production and research.
2. Eng. Agr. Zurita, Santa Cruz, for advanced training on soybean breeding and production.
3. Eng. Medina, Chinoli, for advanced training in potato seed production. Currently scheduled to go to Perú in 1976.
4. Eng. Vildozo, Chinoli, for advanced training in cereal breeding. Currently scheduled to go to Mexico in 1976.
5. Eng. Moreira, Toralapa, for advanced training in potato breeding. Currently scheduled to go to Perú in 196.
6. Eng. Alarcón, Toralapa, for advanced training in potato production. Currently scheduled to go to Perú in 1976.

Other specialties where there is an immediate need for trained personel include:

1. Entomology
2. Plant pathology
3. Weed science
4. Soil science
5. Agricultural engineering
6. Irrigation management

It is strongly recommended that two people who are very critical to the total program immediately be sent for Ph.D. training. These are:

1. Eng. Claure, Toralapa, for Ph.D. training in potato breeding. Eng. Claure returned with his M.S. in 1974 and is well qualified and well motivated for this training.
2. Eng. Salamanca, San Benito, for Ph.D. training in cereal breeding. Eng. Salamanca returned with his M.S. Mexico in 1975 and should be sent now for this advanced training.

Short-term Advisors

The following specialists are needed during 1976. Some can be of value during the current growing season and some would be effective only when the next growing season gets underway.

1. Entomology
2. Deciduous fruit culture
3. Agricultural engineer
4. Soybean genetecist
5. Weed specialist
6. Irrigation specialist
7. Rice specialist (diseases)
8. Vegetables
9. Agricultural economist on small farm technology

The need for improving the competence of Bolivian technicians is paramount to the future agricultural research. But we believe the effect of any training program will be emasculated unless salary schedules for competent technicians are changed. Salaries must be increased considerably above current levels in order to maintain and attract competent scientists in the agricultural sector. Without this incentive, the Ministry training program will fail as competent scientists trained at Ministry expense migrate to more remunerative employment outside the Ministry.

Budgets and Financing

The current mothod of funding the various stations is ineffective. Although budgets may be prepared and approved, there is no guarantee that the money will ever be made available for station programs. The money may go to the department office and be diverted to other projects or it simply may never be disbursed. The project leader is without resource control in his research program. The end result is very poor and frequently far below his capabilities. The role of Obras Públicas in Santa Cruz presents additional and peculiar problems for that area. This Committee approves both funding and programs and allocated funds on a periodic basis, almost project by project. By this system, they essentially control the program scope when this responsibility should be in the hands of the technical specialists.

There is also need for a high level policy decision with respect to financing agricultural research in Bolivia. We believe the costs of such programs must be borne exclusively by the national budget. Stations cannot effectively pursue research when parts of their time and money resources are directed to revenue producing activities. Such arrangements elsewhere, to the best of our knowledge, have been catastrophic. "Commercial farming" phases of experimental stations are likely counterproductive and extremely inefficient. If, in fact, revenue production is needed within the agricultural experiment station system in Bolivia, we recommend that this function be managed apart from the research program and not by research technicians. Revenues from these activities should be deposited to the general agricultural accounts of the Ministry. Individual station financing should be directed to each station by the Ministry and the individual station budgets should have no bearing on whether or not revenue is generated at the station.

There is a need for considerably more guidance in the annual research evaluation and budgeting process. Each project must receive an annual in-depth review by the National Research Director, his CID counterpart, the National Director of Extension, his CID counterpart, and the individual station Co-Directors. The budget for each individual research project will be established and funds allocated on the basis of these reviews.

The end result of this funding process is to put money and other resource control of the program with individual project leaders. He should not have to plead with the station Director nor any Ministry Department office for those funds required to travel, buy fertilizers or seeds, make minor equipment repairs or other things that come up in the day-to-day operation of his research program.

Information Dissemination

In the final analysis, a research program should be judged on how much or how well technology is adapted and applied to real farming conditions. The user is frequently the local farmer but may be researchers and farmers in other localities. Applied research, therefore, is not complete until the technology is formally reported in a form that is readily available to the extension service and, through them, the farmers.

The current system of research information dissemination is very inadequate and does not promote a professional attitude among agricultural researchers. Results are commonly not published. To remedy these deficiencies and to promote improved dissemination of research results, we recommend the following types of publication be initiated and/or used by research technicians:

1. Station annual reports (not a publication *per se*)
2. Extension leaflets, periodic situation reports, etc.
3. Technical research bulletins
4. Bolivian Agricultural Journal
5. International journals

Station Annual Reports

An annual report will be required for every project. In this the project leader will supply the basic research data along with the necessary statistical interpretation and evaluation. The annual report should be the repository of all collected data and observations together with sufficient statistical analysis and descriptive narrative to allow any qualified reviewer to evaluate the conclusions derived from the data. This report should be the working document from which any publication can arise. The annual reports will have a limited distribution, primarily within MACA and should be utilized when projects are considered for renewal. Since the annual reports should be technical, they will be of limited use as an extension tool.

Extension Leaflets

Extension leaflets take the research information or new techniques directly to the campesinos via the Extension Service. Since these

usually emphasize only one concept, they should be published periodically whenever the information is ready for release. The leaflets should be prepared by the research workers, the extension workers, or, preferably, by joint effort. These publications, together with field demonstrations, are the key to success of the research program if we evaluate applied research by the flow of technology to the farmer. There should be developed a series of market situation and projection reports. These should be written as needed to help the farmer, the extension agent and the banks giving credit with such things as market and price projections for the various crops.

Technical Bulletins

The technical bulletins should report information on a research program when it has been carried to some logical point. The style should be technical and should be of value primarily to other research workers in the field. The writing should be of a caliber to match international publications. The technical bulletins should be published by an editorial committee appointed within MACA. Technical bulletins will be rather long and contain extensive tabulations of data. The size of such reports usually will not permit publication directly as journal articles.

Bolivian Agricultural Journal

It is recommended that a journal of Bolivian agriculture be published on a semi-annual or annual basis for research papers from any area of agriclture research. These papers should be technical, but should be of interest and of a level to be understood by researchers in agriculture outside of the researcher's field. A review panel should be selected from among the author's peers. Every paper should be reviewed by at least two of these reviewers before being accepted for publication. The papers should be of the quality of those currently appearing in the various international journals. The editorial committee within MACA should set the standards of quality and of information suitable for such publications. Journal articles would be similar to technical bulletins, but would be shorter and more succinct.

International Journals

Basic research information that would be of value to international interests should be submitted for publication in any of a number of international technical journals. These papers would be highly technical, and, of course, subject to review by outside reviewers. It would be desirable that an internal review (by members of the review panel set up for reviewing papers in the Bolivian Agricultural Journal) be given to all such manuscripts before they are submitted to any international journal.

Summary and Recommendations

In summary, the following recommendations are made:

1. That Bolivia make every effort to educate (at least to Master's level) students who will fill most of its technical needs (research stations, universities, other agencies, private industry, etc.)

2. That agricultural research in Bolivia be supported from appropriated funds and allocated directly to individual stations and that revenue producing functions of the stations be terminated or managed apart from the research program.

3. That increased emphasis be given to national control and direction of individual station programs. This authority is centered in the office of the National Research Director and annual, in-depth, project reviews by the National Director, his CID counterpart, the National Extension Director, his CID counterpart, and the individual station Co-Directors should be conducted.

4. That land resources for agronomic research be limited to 30 to 40 hectares, and equipment be identified and maintained especially for research purposes.

5. That the agronomic research at Saavedra be transferred to a new location nearer to Santa Cruz, possible in cooperation with the research station being developed by the University.

6. That, since the "service centers" incorporate both extension and research, they be built at the research stations, i.e., Toralapa, Chinoli, and the new station in Santa Cruz.

7. That the physical facilities be improved at all stations, with particular reference to electricity and road deficiencies. The specific needs are developed apart from this report in the various lists prepared for use of the T-053 loan funds.

8. That the proposed program to construct soils and plant laboratories at each station be carefully considered. Any construction should be time phased with the first laboratory at Cochabamba. However, we find merit in improving existing laboratories first.

9. That current research programs be given more focus and stations be designated as centers for specific crop research.

a) Because there is only one station in Santa Cruz, this station should direct basic research in corn, rice, soybeans, and sorghum. A breeding program in soybeans should be initiated.

b) Toralapa should be the potato research center. A potato breeding program should be initiated with continued emphasis on variety selection and cultural practices.

c) San Benito should be the center for cereals research. Research on barley should be itensified. (Our competence

does not allow us to evaluate the fruit program. Consultants should be employed for this.)

d) Chinoli should be a center where regional trials and demonstrations are conducted under direction from the crop research centers.

10. An irrigation expert should be obtained to evaluate these potentials and provide program focus.

11. That a training program be initiated immediately to send competent technicians for advanced training. This is an opportune time since CID technicians can assume responsibility for specific programs during this absence.

12. That short term advisors be employed to assist in specific problems until technicians can be trained, i.e., weed control, irrigation, insect control, plant diseases, agricultural engineering, agricultural economics.

13. That more research effort be given to developing and evaluating intermediate technology for farm management. More emphasis must be given to working at the technological level of the farm in attempting to change or improve the cultural and agronomic practices.

14. That the extension personnel be more actively involved in research development and that research personnel take a more active role in information dissemination.

15. That salary schedules for agricultural technicians be escalated if proposed advanced training programs and suggested reforms are to be effective.

16. Seed production and multiplication should be separated from the activities of the research station. The production of foundation seed is a function of the research station, but seed multiplication should be handled by another agency.

17. In addition to being recorded in station annual reports, the research results should be published where they can be used, i.e., (1) Extension leaflets and periodic production forecasts, (2) bulletins, (3) Bolivian Agricultural Journal, and (4) various international journals.

This document represents an initial assessment of the situation on the Agricultural Experiment Stations under jurisdiction of the CID contract. The report, of necessity, emphasizes deficiencies and is critical of much of the existing research program. We do not wish to belie the desperate condition of agricultural research in Bolivia since improvements must be made if general agricultural development and social progress are to be achieved. But we do see positive factors. The Ministry now has loan resources for procuring needed equipment and for constructions. Furthermore, Bolivian technicians have demonstrated their ability to do effective agricultural research. Finally, we are impressed with the dedication and technical competence of many of the technicians

working at the stations. What is required now is a concerted and co-operative effort to develop physical facilities, technical competence and program focus. Time is of the essence.