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1ST ANNUAL PROGRESS REPORT

"Development of Weed Control in Less Developed Countries"

USAID/Oregon State University

Regional Contract No. AID/csd-1442

Submitted July 1, 1967

by

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DEVELOPMENT OF WEED CONTROL IN LESS DEVELOPED COUNTRIES

AID/Oregon State University

ANNUAL REPORT

The objectives set forth in the first phase of the program "Weed Control in the Less Developed Countries" have been achieved. These objectives were: (1) contacting personnel in weed control research in each country in Latin America; (2) compiling information regarding the status of weed control research and interest in Latin America; (3) compiling all the available literature published in Latin America on weed control; (4) establishing a close working relationship with the world chemical industry; (5) training of Oregon State University/AID personnel to be located in Latin America; and (6) making an on-site country survey of all of the Latin American countries under consideration as centers of operation.

With the completion of phase I of the program, phase II will be initiated on July 1, 1967. Phase II will involve the establishment and staffing of centers for research in specific Latin American countries. During the initial period of phase II of the program, in-country surveys will be made of all the major agricultural regions to determine (1) the weed species present in crops, waterways and other areas and which may interfere with human or animal activities; (2) the agronomic practices followed in each crop in each region; (3) to contact personnel involved in research throughout the country and to determine the nature and extent of their work; (4) to determine the nature and extent of weed control practices followed by the farmers of each region; and (5) to conduct experiments to measure the nature and extent of losses in quantity and quality of crops due to weeds.

The first center to be staffed will be Colombia, which will also serve as the South America regional center. Dr. Juan Cardenas has been assigned to that post and will be located there by July 1, 1967. The other four regional centers will be staffed and in operation during 1968. Prior to departure to their respective posts, the staff members will receive in-field training in Oregon and Hawaii. It is strongly recommended that they take part of their training at the University of Hawaii, College of Tropical Agriculture since many of the weed problems and agronomic problems in Hawaii are the same as those found in many Latin American countries.

Research and teaching personnel engaged in weed control in each of the Latin American countries were contacted and informed of the program. Cooperation from these research workers has been very enthusiastic and a continuous exchange of correspondence has been established with many of them. In particular, excellent cooperation has resulted in the compilation of a syllabus of common names of weeds used in each of the Latin American countries. At present the syllabus is nearly completed and, when completed, it will be distributed to all those engaged in weed control in Latin America. Through the compilation of the syllabus it has been possible to obtain a cross section analysis of the weed problems common to

all Latin American countries. At a later date the analysis will be published and made available.

In addition, conversion tables have been prepared for distribution in order to encourage a uniform use of standard metric measures when reporting experimental results in technical publications and at meetings.

The availability of the book Manual de Control Quimico de Malezas, written by Ing. Salomon Zaviezo of Chile was brought to the attention of the world chemical industry and this resulted in orders for more than 200 copies of the book.

In order to compile a collection of publications on weed control from Latin America, all available Latin American Journals were reviewed at the National Agricultural Library in Washington, D. C. More than 150 publications were obtained and currently these are being reviewed. From such a review, efforts will be made to gain information concerning the most serious weeds, where they occur, and how much damage they cause. In addition, a bibliography will be prepared, printed and distributed to all weed control research workers in Latin America and to industry technical staff personnel.

The review of the literature which has been carried out to the present time indicates that there is a critical need for delineation of the nature and extent of the weed problems in specific crops. In order to attack these problems more effectively, the basic problems should be well understood.

Personal contact with the majority of the international division personnel of the world chemical industry has been achieved and full support has been offered to the program. The companies have offered, in addition to commercial products and experimental products for research, the full cooperation from their Latin America in-field staff.

Four major meetings were attended by personnel to be located in Latin America: the Weed Society of America meeting in Washington, D. C., the Western Weed Control Society meetings in Phoenix, Arizona, the Oregon Weed Control meeting in Portland, Oregon and the first Asian-Pacific Inter-Change "Weed Control Basic to Agricultural Development" meeting held in Hawaii. Specific interest was placed on the organization and conduct of the meetings, and on the establishment of personal contact with other members in attendance, including personnel from the world chemical industry. Of special interest was the meeting of the Asian-Pacific Weed Control Interchange. In addition to having an excellent program including the presentation of technical papers, research progress reports and reports on the status of weed control in each of the Asian and Pacific countries, field tours were taken to sugar cane, rice, banana, pineapple, taro, papaya and pasture fields. Of special significance was the formation of the Asian-Pacific Weed Science Society. A similar society for Latin America is in the making and the Weed Science Society of America has laid the groundwork for such a society. The Weed Science Society of America

passed a resolution to make the next meeting a Pan-American meeting and efforts are being made to have representatives of each of the Latin American countries in attendance and participating in the sessions and panels.

In September, 1967, the ALAF (Asociacion Latino-Americana de Fito-tecnia - Latin American Plant Science Society) will hold its 7th annual meeting in Caracas, Venezuela and efforts are being made by Latin American research workers in weed control to have, for the first time, a section on weed control.

In early 1967, Dr. W. R. Furtick and Dr. J. Edwards made a survey trip through 15 Latin American countries to determine the location of the centers of operation. The following is a report of their trip and their recommendations.

LATIN AMERICAN TRIP REPORT

Oregon State University/AID Contract

"DEVELOPMENT OF WEED CONTROL IN LESS DEVELOPED COUNTRIES"

W.R. Furtick and J.A. Edwards

COUNTRIES VISITED: Guatemala, Salvador, Honduras, Nicaragua,
Costa Rica, Panama, Colombia, Venezuela,
Ecuador, Peru, Bolivia, Chile, Argentina,
Uruguay, and Brazil.

DATES OF VISIT: February 17, 1967 through April 8, 1967

SUBMITTED BY: W.R. Furtick
April 26, 1967

SUMMARY

Latin American Trip Report

Oregon State University/AID Contract

"DEVELOPMENT OF WEED CONTROL IN LESS DEVELOPED COUNTRIES"

W.R. Furtick and J.A. Edwards

Fifteen South and Central American countries were visited between February 17 and April 8, 1967. The proposed project was explained to mission personnel and appropriate nationals. To the extent possible, the interest, facilities and personnel available for participation in this project were reviewed. An effort was made to determine the major problems caused by weeds, and some of the economic factors relating to weeds and their control. In general, the response to the program was enthusiastic. The weed problem is serious in all areas and has received only minor attention with a few exceptions.

As a result of this survey, the recommendation is made that five regional study sites be staffed as rapidly as possible. Each study site will coordinate work by nationals at the site and other sites within the region in addition to conducting research. Central America is proposed as one region with site headquarters in either Guatemala, Salvador, Costa Rica or Panama. Four regions are proposed for South America as follows: Colombia, Venezuela and Ecuador with headquarters in Colombia; Peru and Bolivia with headquarters in Peru; Argentina, Chile, Uruguay and Rio Grande do Sul region of Brazil with headquarters in either Argentina or Uruguay; and the tropical area of Brazil as a single region.

It is recommended that all study sites work on certain common objectives in addition to specialized problems of each region. General objectives would include detailing the weed problems by crop, production methods, and climate for each agricultural region, determining the losses caused by weeds in specific crops and relating these to the economic factors that relate to control, and determining the interrelationship between weeds and response to fertilizer and improved varieties.

Adaptive research to determine the applicability of methods being used in North America and Europe will be used to determine if known solutions exist for problems in major crops for each region. In-depth research will be initiated on the most important problems such as nut-edge, kikuyo grass, jungle clearing and similar problems.

Major support facilities required from the central staff in Oregon and consultants are detailed in the report. The report also includes observations made in each country on the reaction to the program, major problems and details on staffing needs, operation and research priorities.

LATIN AMERICAN TRIP REPORT

for

W.R. Furtick and J.A. Edwards

OSU/AID Contract

"DEVELOPMENT OF WEED CONTROL IN LESS DEVELOPED COUNTRIES"

Purpose of Trip

The primary objective of this trip was to explain in detail the purpose and possible methods of operation for the in-field research program to be conducted under the AID regional contract for Development of Weed Control in Less Developed Countries. An effort was made to assess the level of interest, facilities, staff, and support capabilities of the agricultural institutions and the AID missions in those countries expressing an interest in participating in this program.

To the extent possible, the major problems being encountered with weeds in the production of the primary crops in each country were evaluated as a means of determining the primary priorities of weed control research when the project is initiated. The economic factors that might influence the establishment of research priorities were explored to the extent that information was readily available.

Countries Visited

Fifteen Latin American countries responded to the original aerogram requesting their expression of interest for a site visit. The countries visited were Guatemala, Salvador, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Peru, Bolivia, Chile, Argentina, Uruguay, Brazil and Venezuela.

Dates of Trip

The survey trip started in Panama on February 17 and ended in Guatemala on April 8, 1967.

General Response of Mission Personnel and Nationals to the Program

Weeds appeared to be a major factor limiting agricultural production in every country and region visited. In general, there was an awareness of the weed problem by both the mission personnel and the various agricultural organizations within each country responsible for agricultural research and extension work. These organizations included the national experiment stations, extension services, universities and the representatives of private industry organizations. With a few exceptions it was obvious that very little organized research or extension effort had been devoted to weed control problems. This contrasted markedly with programs

for the control of insects, plant diseases and plant breeding. There was also a much more rapid development of soil fertility work compared to weed control. It was evident that research workers had not given serious recognition to the magnitude by which response of weeds to fertilizer could limit the true fertilizer response of crops; however, a few workers did point out that weeds were such a serious problem that it appeared they made the use of fertilizer questionable.

There was essentially unanimous agreement among both the mission personnel and the agricultural leaders of each of the countries visited that the AID project "The Development of Weed Control in Less Developed Countries" was badly needed in their country and could make a major contribution to the development of their agriculture. In almost every case there was an apparent willingness and desire to contribute those resources which could feasibly be shifted for participation in this program.

The presently available competence of personnel and facilities varied widely from country to country. The highest degree of facilities and competence appeared to be available in Colombia. Although the facilities and personnel were more limited in Peru, there were also substantial facilities available and extremely active interest in the program in that country. A wide range of facilities and several trained personnel with interest in the weed control field were available in Argentina. The mission personnel in Argentina requested that one site for the project be located in Argentina. The interest in Uruguay was very keen, although the availability of trained personnel was much more limited. Substantial interest and facilities were also available in Brazil. In the Central American region, the greatest level of interest was expressed by the mission personnel and the nationals in Guatemala. Considerable interest was also expressed by the mission staff and nationals in El Salvador and Panama. Although the interest and the need appeared to be more substantial in the other Central American countries, there were less facilities and staff available to devote to such a program. All of the countries wanted to be either participants or cooperators in the regional project but several did not appear to have the capability for acting as a center for the program.

Summary of Findings by Countries

Colombia

Of the Latin American countries, Colombia is expending the greatest effort to establish an effective weed research program. This is under the auspices of the Federal Agricultural Research Agency "ICA". A new staff consisting of five ingeniero agronomos has been hired to establish a coordinated weed control program under a new weed control department headed by Dr. Miguel Revelo. This project is presently being aided by Dr. Larry Jeffery under an AID contract with Nebraska. The new staff on this project had no previous training in weed control and will need a major amount of guidance in order to develop an effective program. The weed control problems in Colombia are extremely diverse and are known to be a major factor limiting crop production. Where data have been collected on their relative importance, the indications are that losses range as high as 50% of the potential crop production in crops such as rice, cereal grains, and tropical plantation crops.

Colombia would appear to offer an excellent site for a major center of operations because of the great diversity of climatic areas ranging from the highlands to coastal tropics with all types of intermediate climate depending on elevation. Practically all of the world crops are grown in Colombia under diverse climatic and soil conditions ranging from temperate zone conditions in the highlands to the very hot, humid coastal tropics.

Participation in the Oregon State contract program was enthusiastically endorsed by the ICA staff, included Director Fernando Penaranda, the administrative staff and specialists of the Nebraska contract, the Rockefeller Foundation, and the AID Rural Development Officer, Norman Ward. It was agreed that the contract program should be closely coordinated with the Nebraska contract and that Oregon State staff should work as exoficio members of the Nebraska contract team in Colombia but that Nebraska would not exercise control over the technical and operational aspects of the program. This approach was in line with the desires of the administrative staff for the AID country mission, Rockefeller Foundation, and was agreeable to the Nebraska contract staff.

Colombia appears logical as a major research site and as the in-field headquarters for the Latin American program because of the convenience of travel, the diversity of problems, the excellence of experiment stations, and because they are the site for the initiation of a regional tropical agricultural graduate research institute. Because the AID mission would not be able to furnish adequate transportation for project of this type, it was agreed that the Oregon State University contract would furnish a vehicle and that Juan Cardenas would be assigned as coordinator for the Latin American region with headquarters in Bogota. Plans were initiated for this move to be effective as near July 1, 1967 as possible. It would

appear logical that the Colombia research site should be utilized to coordinate supplemental work in Ecuador and Venezuela.

The major weed problems in Colombia were discussed with Dr. Miguel Revelo, Director of Weed Research for ICA. He feels that only limited research information is available on the importance of weeds. So far their program has been devoted almost entirely to testing and approving herbicides under a fee arrangement with industry. This job is partly research, but primarily regulatory. All companies must submit products for test on the crops for which they are to be sold. If the product is approved by the ICA staff as suitable under conditions in Colombia, it is licensed for sale. The company is charged a fee to cover the cost. Discussions with representatives of duPont and Rohm & Haas companies indicated industry was satisfied with this program and pleased with the way it was conducted. The volume of work under this program has not permitted the depth of research needed to determine the details of the weed problems and find acceptable solutions to the extent desirable.

Under the licensing program a number of herbicides have been introduced and there is rapid adoption taking place on certain crops, particularly rice and cotton. The most dramatic illustration of the impact herbicides can have is illustrated in rice production. The product propanil was introduced a few years ago to control barnyardgrass Echinochloa crusgalli selectively in rice. Yields were increased to the extent that growers who did not adopt this new practice were unable to compete, so now all of the Colombia rice acreage is treated. Undoubtedly similar situations exist with many other crops on which effective control practices have not yet been introduced. Dr. Revelo feels that an intensified research program would produce enormous benefits and that adoption of weed control practices would follow a pattern similar to the response given to chemical weed control in rice.

Ingeniero Enrique Rodriguez of the ICA horticulture project indicated 50% of the cost of producing tomatoes was due to weed control. Costs of hand labor for weeding vegetable crops such as tomatoes, beets, carrots, and melons was approximately 3,000 pesos (\$200) per hectare. In addition, the weeds made insect and disease control more difficult.

Discussion of potato production with Ingeniero Nelson Estrado, potato specialist for ICA, indicated that 4% of the larger growers produced 70-75% of the potatoes. This would indicate that the production unit in many cases is large enough to justify mechanization of the weed control practices.

The weed problems in Colombia were also discussed with representatives of duPont, Rohm & Haas, the Rockefeller staff, and Dr. Larry Jeffery, weed specialist of the Nebraska contract.

The most important weed control problems that appear to be of concern in Colombia are control of kikuyo grass Pennisetum clandestinum on the highland areas, control of nutsedge in all tropical zones, control of

bermudagrass and johnsongrass in the tropical areas and control of a wide range of annual weeds, particularly barnyardgrass and various aquatic plants in rice. Other weed problems include a wide range of species plaguing production of small grains, corn, beans, cotton and vegetable crops. In the coastal area there is interest in developing weed control methods for plantation crops, particularly bananas, coffee, cacao, sugar cane, citrus and pineapple. Because of an extensive colonization program and interest in tropical pasture development, there is substantial interest in research on jungle clearing and tropical pasture management to provide high quality tropical pastures without serious weed problems.

Ecuador

At present there is no organized weed control research in Ecuador. Some initial work in weed control is being conducted by the National Agricultural Research Organization "ENIAP" primarily through the research station at Santa Catalina near Quito. During the stay in Ecuador, visits were made in company with C. C. Cummings to the tropical area on the coastal region with trips to the experiment stations at Pichilingue and Santo Domingo. At these stations weed problems were very apparent in corn, beans, cacao, bananas, oil palm and pastures. A major problem in Ecuador is a chemical means of eradicating bananas as a means of easily converting excess banana acreage to other uses, particularly production of corn or tropical pastures. In the highlands in the region of Quito unusually serious weed problems were observed in cereals, corn, potatoes, and pastures. It would appear that a substantial amount of Ecuador's production is lost because of weeds. There is almost no efficient weed control currently practiced in Ecuador.

The National Agricultural Research Organization ENIAP was very enthusiastic about the possibility of collaborating on a program and were willing to have their personnel devote substantial efforts in weed control if adequate consultation could be provided to be effective in conducting such a program. The AID mission and Rockefeller Foundation personnel were also very enthusiastic about participation in the weed control work on jungle removal as part of the AID program supporting colonization. This project was enthusiastically endorsed by mission Director Oechsley as well as RDO R. L. Winters and his associate C. C. Cummings. Both the mission staff and the Rockefeller staff were very hopeful that a staff member might be stationed in Ecuador under this project.

Peru

A high level of interest was demonstrated by the Peruvians in this program, particularly by Alexandro Corrales who presently is in charge of the weed control program at the La Molina experiment station near Lima and Ernesto Bullon of the Terapoto experiment station. Peru has only these two men presently devoting time to weed control. The Terapoto experiment station is a jungle station on the east side of the Andes. Ingeniero Bullon is devoting his primary effort to combating jungle and trying to develop improved tropical pasture management. He is very en-

thusiastic about the possibility of participating in this program with keen interest in jungle clearing, pasture management and weed control in tropical crops, particularly control of nutsedge and similar species.

Weeds are a serious problem in the irrigated coastal plain with nutsedge being of serious consequence in this whole region. A wide range of other problems exist in crops, including rice, cotton, corn, potatoes, citrus, sugar cane and various plantation crops. There are also considerable weed problems in evidence in the highlands where the primary crops are potatoes and corn.

A keen interest in participating in the weed control project was expressed not only by the administrative staff and specialists of the National Research Organization, but there was also strong interest expressed by the staff of the North Carolina contract and the AID mission. The North Carolina administrative staff pledged close cooperation with the program and the Oregon State staff would act as exoficio North Carolina staff. Meetings were held with all of the representatives of the chemical and equipment industries and they offered their full support of any program that could be established. Because of the diversity of the problems in Peru and the unique problems posed by the production practices in the arid irrigated coastal plain, it would appear that Lima should be the site headquarters for a major research effort with this staff responsible for supplemental work in Bolivia.

Bolivia

During a brief visit to Bolivia research work at the primary high elevation experiment station near La Paz was reviewed and weed problems in this region observed on farms. Discussions with the Ministry of Agriculture technical staff, Utah State University contract staff, and mission personnel indicated that the research efforts of the Bolivian Ministry of Agriculture is somewhat limited. There is an effective extension program which appears to be doing a capable job and improving rapidly under good management. The interest in weed control was keen with particular interest in the introduction of the chemicals or other improved methods for control of weeds in cereals, potatoes, corn and alfalfa in the higher elevation valleys along with development of jungle clearing techniques and weed control in tropical plantation and food crops in the tropical lowlands. A serious problem with nutsedge is present in the tropical areas. The major push in Bolivian agriculture will be to develop the tropical lowlands where serious weed problems are encountered.

It would appear from the minimum support capability and staff participation available in Bolivia, that the only participation under the regional weed control project would have to be limited to furnishing consultation and encouragement to the Bolivian Ministry of Agriculture towards the end of the eventual establishment of an effective weed control program. Certain adaptive research might be conducted by some of the extension service staff.

Chile

Inadequate time was available in Chile to thoroughly review the weed control work being conducted in the Santiago area and the central valley. Brief visits were made to review the research work at Temuco, Chillan and Santiago. Excellent research programs have been established in Chile by Chilean staff with advanced degree training in weed control from Oregon State University. This gives Chile one of the most effective weed research and extension programs in Latin America.

Because of the relatively high level of development in the Chilean weed control research program, it would appear that they could best be brought into the regional project on a consultation basis and could conduct all necessary in-field research to accomplish project objectives with only consultation. They could become a valuable part of the program by considerably expanding the research potential without the need for long-term resident staff.

Argentina

Four experiment stations were visited in Argentina which represented a cross section of the type research facilities available through the National Agricultural Research Organization "INTA". These stations included one at Pergamino which is the primary research station for corn, sorghum, sunflower, and irrigated pastures. Enormous weed problems were observed in these crops with various species of crabgrass being the dominant weed species. The station personnel indicated that they were unable to obtain a fertilizer response for crops in the Pergamino area. It was obvious from observing the research work that the marginal precipitation coupled with the extreme density of weeds made use of added fertility doubtful as a means of increasing yield because weed response would deplete the available moisture.

The experiment station at Raphaela was visited. A staff member trained in range weed control at Nebraska was very helpful in reviewing the problems. This station services primarily the dairy industry with the primary research being on alfalfa for grazing and sorghum production. The worst problem of this region is the invasion of alfalfa by a non-palatable *Stipa* species of perennial grass called pastapuna. Within two years after seeding a new stand of alfalfa it is essentially eliminated with complete invasion of this grass. This appears to be tied, primarily, to poor management and the best solution would appear to be changing the grazing management of alfalfa. Sorghum appeared to have serious limitations as a grain crop primarily because of the problems with weeds. Sorghum is planted in a dense solid stand to smother weeds. Most years this prevents harvest for grain due to inadequate moisture available for the density of stand planted. In wet seasons, suitable grain yields are obtained but in the drier years the sorghum is harvested by grazing. This region has serious brush problems and the Raphaela station has demonstrated that the primary brush species can be readily controlled with a chemical injection tool designed by station personnel.

Two intensive vegetable and fruit crop stations were visited, one at Oliveras and the other at San Pedro. Both of these stations were much smaller than the previous stations visited, however, they had substantial facilities and staff. Both stations had conducted a small quantity of weed control work and were very interested in an expanded weed control program. Nutsedge was a primary problem and was a limiting factor in the production of strawberries, lettuce and other vegetable crops and a serious competitor with citrus fruits. The research that had been conducted was limited and in some cases work that had already been conducted in California and other locations.

Vast areas of high quality pasture lands completely dominated by Castilian thistle were observed during this trip. The weed problems in Argentina appeared to be more serious than most other areas of Latin America visited. The weed control research program of INTA is quite limited, primarily due to lack of trained staff to direct the programs. There is a vast experiment station network in Argentina with a large total agricultural research staff. The interest in weed control research appeared to be keen at all locations and the primary ingredient lacking was technical assistance. It would appear that substantial progress could be made in determining the importance of weeds in Argentina and building the data necessary to show the return from the introduction of improved practices if technical assistance could be given the present research organization.

During the stay in Buenos Aires, a conference was held which was attended by the representatives of the agricultural equipment and chemical industry, staff from the Ministry of Agriculture and the weed control research representatives of INTA. These were members of a weed control council that has been operating for several years to promote and distribute information on weed control. They were very enthusiastic about the possibility of collaborating in the regional AID project and agreed to get together as much information as possible on weed control losses and present practices as a first step in aiding the establishment of this project.

The Rural Development staff in the Buenos Aires mission was keenly interested in participation in the regional project and was quite anxious to see Argentina as a headquarters site. It would appear that Argentina would offer substantial potential for a major effort under this regional project.

Uruguay

During the stay in Uruguay conferences were held with the research staff of the Ministry of Agriculture dealing with horticultural crop production, forestry, and representatives of the diversified crop experiment station at Estensuela. There was a keen interest among all of the Ministry staff for participating in this program. They all agreed that weeds were of enormous importance in Uruguay and the problems ranged from serious brush control problems that are limiting the utilization of much of the vast grazing lands of Uruguay to weed problems in vegetable

and orchard crops along the Plata River. Extensive weed problems exist in corn, small grains and improved pastures. The establishment of more effective weed control could have a substantial impact on agricultural production.

There was substantial interest by the forestry staff in utilizing selective grass control in conifer plantations which are being established as part of a forest industry program to convert certain grass lands into forest plantations. Some of the research on converting grass lands to forestry in Oregon would quite possibly be applicable to solving their problem. This would appear to be most effectively handled through short-term consultation with the forest weed control staff that has dealt with this problem in North America.

The AID mission staff were unusually enthusiastic about the place the weed control program might have as part of their major agricultural development project of increasing wheat production, improving pastures and developing a forestry industry. The mission staff were very anxious to have Uruguay as a headquarters site under the regional contract program.

The interest and problems appeared adequate in Uruguay to justify a major program in this country.

Brazil

With the vast size of Brazil and the short duration of the visit coupled with it coinciding with the Easter holiday period, it was difficult to cover very much area on a site visit of this type. Visits were made to the National Experiment Station near Rio de Janeiro, the federal experiment station at Sete Lagoas near Belle Horizonte and the state experiment station for the state of Sao Paulo at Campinas. In addition, a visit was made to the Biological Institute in Sao Paulo. The weed problems in Brazil are as diverse and as large as the country. Since Brazil produces most cultivated crops in quantity and the majority of these are grown under tropical conditions, weeds are usually a very serious production problem. The most intensive weed control work now being conducted in Brazil is under the auspices of the State of Sao Paulo. This is divided between the staff of the Biological Institute and the state experiment stations. They have very limited staff and they are short on professional training in the weed control area and could profit substantially by consultant help. There was keen interest on their part in collaborating in the regional AID program and it was obvious that there was a high level of interest by the National Research Organization in Brazil. The same was true of the IRI contract group working with AID. The suggestion of the mission staff was that the project be centered at either Sete Lagoas or at Campinas which is the location of both a federal experiment station and the State of Sao Paulo experiment station. It would appear that the greatest diversification of work could be accomplished by locating in Campinas with Sete Lagoas as a subsidiary study site. The problems of the Sete Lagoas area

primarily devoted to tropical pasture development where the problems of clearing low tropical jungle for conversion to pastures was observed in detail. It would appear that an herbicide program could increase the efficiency of new land clearing and prevent the constant machete maintenance of brush regrowth on pastures that have been established. The present methods involve machete labor with a cost of over \$100 per hectare for initial labor and \$10 to \$20 per hectare annual machete maintenance to keep the jungle from re-dominating the pasture area.

The experiment station complex in the Campinas area deals with essentially all of the major crops produced in Brazil and the weed control problems are typical of most of the low Brazilian upland that accounts for the major areas of crop production. The facilities available are excellent and the staff interest in weed control keen with the director of the state experiment station at Sao Paulo a professional weed control scientist.

In order to review the regional project proposal with the research workers and industry representatives in Brazil, the Brazilian Weed Conference held a national meeting in Sao Paulo and the program was presented to approximately 70 people attending this special meeting. The reception was excellent and industry and research workers pledged their cooperation if the regional project was established in Brazil.

Because of the magnitude of the problem, the facilities available and the level of interest, it would appear that a program should be established in Brazil with the headquarters in Campinas with a junior staff member located at Sete Lagoas for work on tropical pasture problems.

Venezuela

The brief visit in Venezuela did not permit extensive travel in this country. The Ministry of Agriculture, the Resource Development Department, and the National Park Service staffs were visited in Caracas and the Shell Foundation Experiment Station near Caracas was given a very brief visit. Most of the agricultural research in Venezuela is conducted by the Shell Foundation which also accomplishes most of the extension work. They have an excellent weed control staff and a good research program underway. They expressed interest in collaborating with the regional project and there was substantial interest by the Ministry of Agriculture, Resource Department and National Park Service people, particularly in the area of aquatic weed control on the irrigation systems being developed throughout the country. It would appear from this visit that Venezuela could be utilized as a supporting site for work in Colombia with the work being conducted by the Shell Foundation staff in cooperation with the regional project. There would also appear to be the desirability of exploring the establishment of aquatic weed control work with the aid of consultants.

Panama

The regional program was presented to the Minister of Agriculture and

the head of the Research Department in Panama and was enthusiastically received. The major problem in Panama is the very limited staff available on the experiment stations, but there was general agreement by the Ministry people that weeds are a serious problem in Panamanian agriculture and that they have a strong desire to establish weed control work as a supplement to their Entomology program. Their most important weed problem is nutsedge which is serious in the production of corn, vegetable crops, and various plantation crops. There also was keen interest in work on brush control in tropical pastures and in jungle clearing for increasing the total arable land. The mission personnel were very cooperative and enthusiastic about participating in the regional project and were very hopeful that the Central American Regional Center would be established with Panama as the headquarters.

It would appear that an effort should be made to utilize Panama as a study site.

Costa Rica

Visits were made to the Minister of Agriculture and the various research department personnel of the Ministry of Agriculture. The director of the experiment station for the University of Costa Rica in San Jose, and the Inter-American States University at Turrialba were also visited. The mission personnel indicated they would like to see the Central American headquarters for the regional project located in San Jose; however, they were, at the time, rather pessimistic as to how much local effort could be stimulated for participation in the program. This appeared to be a correct assessment at the time of the visit due to the limitations in financing for the Ministry of Agriculture. The Minister of Agriculture himself was very enthusiastic about the program and pledged the maximum support he could provide for the program if it were established in Costa Rica. Since returning from Costa Rica, a letter has been received from the mission personnel indicating that as a follow-up, the Minister of Agriculture has established a new department of weed control in the Ministry and hired a director for this program and is very hopeful that serious consideration will be given to utilizing San Jose as a major research area. If this effort is adequately supported, Costa Rica has an excellent potential from the standpoint of diverse problems in an agricultural community that could have a reasonably good adoption rate for discoveries. The primary weed problems include barnyardgrass and other weeds in rice, nutsedge in coffee, corn, bananas, sugar cane, pineapple and vegetable or specialty crops and substantial areas in which jungle clearing is of major importance for bringing new lands under cultivation. A collaborative project has already been conducted by the AID mission with Caterpillar Tractor Company to test large land clearing equipment and this project has demonstrated that this is economically feasible with a fast return on the original investment.

Nicaragua

The visit in Nicaragua was of only one day's duration and permitted

only a brief visit with the Ministry of Agriculture staff. The reception was enthusiastic since the Ministry of Agriculture is developing a new experiment station in the primary agricultural production area along the Pacific Coast. The experiment station director for this new station came in for conferences on this program and was very anxious to have help in establishing weed control as an integral part of the station program. The staff available appears to be limited but the facilities appear to be quite satisfactory for establishing an effective weed control program. It might be feasible to utilize Nicaragua as a subsidiary site to gain broader information on adaptive research programs. They also have interest in jungle clearing and weed control in plantation crops.

Honduras

The visit to Honduras was also limited to one day which provided a chance to visit with Ministry of Agriculture personnel. The facilities for research in Honduras are limited entirely to the efforts by the extension service which has an excellent staff of specialists which conduct developmental research as well as act as advisors for all of the extension agents. This specialist staff was very enthusiastic about the possibility of having consultant help in the weed control area and would very much like to participate in the regional project on this basis. It would appear to be a feasible approach as a means of exploring the general applicability of developmental programs. The mission staff in Honduras was quite favorable to this program and would be willing to devote effort to this project.

El Salvador

A visit was made to the Central Experiment Station near San Salvador but it was not possible to visit with the Ministry administrative staff because of a change in administrative staff that had occurred on the day of arrival. The mission staff were very anxious to see a major weed control effort established in El Salvador and the facilities available at the experiment station were quite adequate to support a program but personnel were limited. In visiting with industry representatives it would appear that El Salvador has the most intensive use of equipment and pesticides in Latin America with weed control lagging far behind use of insecticides and fungicides.

Guatemala

The AID staff in Guatemala was very cooperative and expended substantial effort in trying to encourage the regional project making Guatemala the Central American headquarters. The program was presented to the staff of the Central Research Agency and the research director was very interested in having the program established in Guatemala and pledged his full support towards this program. The coastal experiment station was visited and the director of this station also was very enthusiastic and pledged complete support of his staff in participating in the program should it be established in Guatemala. Time did not permit visitation to the highland stations. The weed problems in Guatemala are extremely diverse and serious.

Nutsedge is a major factor limiting agricultural production. This was very apparent in visiting the National Agricultural Technical School which would also like to participate in the program utilizing student thesis research as a means of training graduates in the importance of weed control and familiarizing them with modern methods of weed control. It would appear that this might offer a good study site because the experiment station for the National Agricultural School has a high diversity of cropping with very serious weed problems. The coastal experiment station is nearly solidly infested with nutsedge which is limiting the utilization of this station. The highland areas include elevations where kikuyo grass is of major importance and because of the diversity of climate, nearly every major crop, both tropical and temperate zone, is raised in Guatemala. This gives Guatemala one of the greatest diversities of agriculture in Latin America with a wide variation in climate.

Summary of Staffing Recommendations

Major study sites should be staffed in Colombia, Peru, Argentina or Uruguay, Brazil, and a Central America location in Guatemala, San Salvador, Costa Rica or Panama. Additional study sites might be staffed with junior staff in Ecuador, a second study site in Brazil and in Argentina or Uruguay depending on the sites selected for the senior staff.

The proposed regions for research in Latin America would include one Central American region comprising Panama, Costa Rica, Nicaragua, Honduras, San Salvador and Guatemala and four South American regions. The centers in Colombia should have responsibility for research in Venezuela, Colombia and Ecuador. A headquarters site in Peru should be responsible for Peru and Bolivia. A site in either Argentina or Uruguay could have responsibility for Chile, Argentina, Uruguay and the Rio Grande do Sul region of Brazil. A fourth South American region comprising the tropical area of Brazil would be desirable.

It is recommended that the in-field leader for the Latin American program be located in Bogota.

All of these regional centers should concentrate on broad objectives that can, as a composite, improve the knowledge of weed control problems in the Latin American region.

Principal Weed Problems

Perennial Grasses & Sedges

1. In much of Latin America the most important single weed problem would appear to be various species of Cyperus, primarily Cyperus rotundus and Cyperus esculentus known as nutsedges or nutgrass. The nutsedges are aggressive perennials, particularly in the tropical zones. They respond vigorously to fertilizer and are extremely competitive with most crops. Nutsedges are the major

problem in almost all row crops and frequently are important in such plantation crops as coffee, bananas, sugar cane, citrus and pineapple. These species were problem weeds in every country visited.

Perennial grasses appeared to be of major importance in many of the crops with kikuyo being the most important weed problem in the highland areas of the Andes and in the other mountain ranges in tropical areas that had agriculture above the 6,000 to 7,000 foot level. This very aggressive stoloniferous plant appeared to be extremely competitive with all crops and prevented establishment of more highly productive pastures on land not devoted to cultivated crops. No known solution is presently available for eliminating this species and large amounts of hand labor are now devoted to raking out the stolons and rhizomes and drying them in the sun for later piling and burning. Other important perennial grasses include bermudagrass (Cynodon dactylon) and johnsongrass (Sorghum halepense). These perennial weeds which are also widely found in North America were common in practically every country visited, but were not as extensive in their infestations as either nutsedges or kikuyo grass.

Herbacious Perennial Weeds

A number of perennial herbacious weeds were obvious problems particularly in those areas with temperate climate conditions. Bindweed (Convolvulus arvensis) and various thistles of the genus Cardus or Cirsium were particularly important in Argentina, Uruguay and Chile. Many of the important perennial herbacious weeds found in North America were apparently problems in Latin America.

Jungle Removal

There is considerable pressure in many of the Latin American countries to remove jungle where the jungle species are not of commercial timber value as a means of bringing new land into cultivation for colonization or other programs. A great deal of interest was expressed in Colombia, Ecuador, Peru, Brazil, Guatemala, Honduras, Nicaragua, Panama and Costa Rica in utilizing chemicals to dry down jungle areas to facilitate burning as a means of converting the land into pastures or crop lands. Research conducted by the University of Hawaii would indicate this procedure might be an economically feasible approach for reclaiming certain types of jungle lands.

Annual Weed Problems

All of the major crops appeared to be plagued by a wide array of annual weeds which were creating highly competitive conditions for nutrients, water and in some cases light. Improved methods appear to be needed to give control on a wider array of annual weeds in rice to supplement the control of barnyardgrass (Echinochloa crusgalli) now widely controlled with the herbicide propanil. In many areas serious annual weed problems exist in

potatoes, corn, sorghum, beans and a wide array of vegetable crops. The economics of immediate introduction of mechanization or chemicals appears to be the most favorable on intensive vegetable crops. In all the crops surveyed it would appear that considerably more money is being expended in hand labor than would be required to utilize chemicals or equipment for more effective weed control. Generally weeds were not being adequately controlled with present methods and large yield reductions are probably resulting.

Plantation Crops

Weed control with chemicals is being explored and in some cases adopted commercially in coffee, bananas, cacao, oil palm, sugar cane, citrus and pineapple. Greatly increased efficiency could be obtained by utilizing chemicals or equipment in these various crops.

Fertilizer-Weed Control Interrelationships

Numerous examples were observed in which it would appear that heavy weed infestations which had resulted from weed response to fertilizers had caused negative or limited crop yield responses from the application of fertilizer. Since there is very little information on these inter-relationships, particularly under tropical conditions, this area should be given top priority in the research program to build data on the weed control necessary in order to effectively utilize fertilizer when introduced under the various major tropical climatic and weed population conditions. Until data can be developed that will give direct measure of the importance of weeds as a factor in yield responses from fertilizer, it is going to be difficult to bring a general awareness of the need for weed control in both research and in commercial introduction of fertilizers.

Aquatic Weed Problems

Serious weed problems exist along irrigation systems with the most frequent complaint being distribution of nutsedge tubers in the irrigation water resulting from bank erosion of ditch banks infested with this species.

Aquatic weeds in irrigation canals and ponds were also frequently mentioned. The problem of water hyacinth appeared to be the most frequently mentioned.

Forest Plantation Problems

Control of grass in establishing new forest plantations and control of other undesirable species appears to be of importance in countries with an active forestry program.

Tropical Pasture Establishment and Weed Control

Converting brush lands to improved pasture and control of brush and other weed species in pasture appeared to be of particular importance in

Argentina, Uruguay, Brazil and to a lesser extent, in all other countries. Effective pasture research is of high priority in many areas.

Recommended Method of Operation for the In-Field Program

In order to obtain the greatest efficiency for accumulating data over the widest area of Latin America, it would appear mandatory to endeavor to concentrate on effectively utilizing all of the agricultural research personnel available, capable and willing to participate in various phases of this program in as many countries as possible. The work of the nationals should be supplemented by direct research work by the AID/Oregon State contract staff with the greatest emphasis on work requiring more depth of study than the capability of national staff would permit.

In order to cover the widest geographic areas in a coordinated manner it is recommended that five primary study sites be established, four of which would be in South America and one in Central America. It is recommended that these sites be established with headquarters in Colombia, Peru, Argentina or Uruguay, Brazil and Guatemala or San Salvador with Costa Rica or Panama as alternates. The in-field headquarters for the Latin American program should be centered in Colombia because of the greater depth of facilities and personnel along with the convenience of travel to South America, Central America and Oregon.

The center in Colombia should concentrate the primary research efforts in Colombia and attempt to supervise collaborative research by nationals in Venezuela and Ecuador.

The research location in Peru should concentrate on the problems of the irrigated coastal area with a lesser effort in the highlands and tropical jungle areas of Peru and Bolivia.

The research location in Argentina or Uruguay should act as a center for study of the temperate zone and semi-tropical zone embracing Chile, Argentina, Uruguay and the Rio Grande do Sul area of Brazil. Since Chile has a well developed research organization with a staff of four people trained in Oregon, the work in Chile can be largely consultation. Argentina has substantial experiment station resources that could be devoted to weed control work or utilized for work by the resident staff. The facilities in Uruguay and the Rio Grande do Sul area of Brazil are less extensive but offer sites where substantial work might be encouraged by the nationals as well as acting as a center for resident staff research.

The center in Brazil should concentrate on the problems of the tropical region of Brazil.

Work in Central America could most effectively be conducted from a center in Guatemala or San Salvador because of the great diversity of crops, climatic areas, and weed problems found in this region. Other alternate centers would include Panama and Costa Rica.

Priority of Projects

1. Primary effort should be devoted to obtaining greater depth of information on the exact type and extent of weed problems in the major cropping areas and major crops of each agricultural production region. This should include a determination of the present control methods being practiced in the various regions and the cost for carrying out the control measures now used. Data should also be accumulated on the yields, price of input such as labor, fertilizer, chemicals and equipment and the prices obtained by the growers for the principal commodities. This information would permit determining the amount of yield increase required from a new practice to make the cost of the practice justifiable. It would also permit comparative data on the cost return ratio of present practices to practices which might be more effective. The total data accumulated on the extent of weed problems for the Latin American region would provide data for the equipment, chemical and fertilizer industries in assessing the extent of the potential market and the economic conditions necessary in order to be able to effectively supply the market. This should make it possible for them to determine the extent of research and development money they could devote to the various potential markets. This data is not presently available.
2. In order to obtain reliable data on the economic importance of weed problems in the various major production regions, research should be conducted to eliminate weeds as a production factor in order to assess the impact of weeds on production and quality under the present agricultural procedures.
3. The third phase of the program should be adaptive research to thoroughly explore the extent to which presently utilized practices in North America and Europe could be adapted with minimum change to the cropping and climatic conditions of the various Latin American regions and crops. If adaptive research can show that either the methods used elsewhere can be adapted directly for solving a major weed control problem or modified sufficiently to be effective, it will permit obtaining data on the magnitude of losses that have previously been suffered from weeds under the production practices now being utilized in the various regions.
4. The interrelationship of weed competition and response to fertilizers and the comparative productivity of various varieties under weed-free conditions should be assessed as a means of determining the importance of weeds as a production factor in the introduction of fertilizer and improve varieties. This data is not presently available.
5. In-depth research should be established to determine the best possible solutions to the most important weed problems already known to exist. First priority should be given to finding effective means of controlling nutsedges with secondary emphasis on perennial

grasses as kikuyo grass, johnsongrass and bermudagrass.

6. Because of the major emphasis on bringing new lands into production, particularly in the tropical zones, a major research effort should be launched to compare the feasibility of various methods of jungle removal and the management of new lands to prevent jungle re-invasion.
7. Specific problems of a more limited regional nature should be undertaken as dictated by the results of the more detailed problem analysis proposed as a primary step.

Major Supporting Research Necessary by the Oregon Central Staff

It is apparent that a large amount of service work must be available from the Oregon central staff in order for this program to function adequately. Initially the most pressing support effort will be the compilation and correlation of the data on weed problems, economic information and results of adaptive research developed by the various regions. On the same basis, the central project will need to compile information on the details of all known weed control practices now being successfully used on the wide array of crops found in the Latin American area. This will be used as a basis for adaptive research to determine those problems where known research methods can be adapted to satisfy the needs under the production conditions of the Latin American regions.

Because the technological advances in North America and Europe are moving at such a rapid pace, it will require substantial effort to keep abreast of these developments and make them available to all the in-field staff. A major function of the central project should be information exchange to see that the in-field staff are kept abreast of the developments in the other regions of Latin America and the technological advances being made in other parts of the world and to make available to the central staff and the collaborating industries the details of results coming out of the Latin American program. This will require substantial effort in compilation and publication of information.

It would appear that many of the major weed problems such as nutsedges, kikuyo grass and similar serious perennials will require greater depth of research than can be adequately handled with the facilities and staff available in Latin America. In order to supplement these efforts, programs requiring sophisticated laboratory facilities should be conducted by the central staff in Oregon.

Because most of the research work conducted by industry and experiment stations in the United States and Europe has been directed at solving problems of the temperate zone, it is highly desirable to expand the new product evaluation program being carried on jointly by Oregon State University and the University of Hawaii to embrace the primary weed and crop species of the tropics in this preliminary evaluation program as a

means of obtaining promising materials for tropical conditions in the shortest possible time. This program which now involves a close working relationship with the chemical industry could readily be expanded without undue cost to provide immediate information that should greatly speed the solution of the tropical problems in the Latin American region and many of these solutions should be readily adaptable to most of the tropical regions of the world. It is, therefore, recommended that the new product evaluation program become an integral part of the AID project and expanded to cover the needs of tropical agriculture.

Consultive Services Necessary

Because of the extreme diversity of the weed problems in the Latin American region, it is highly desirable to have a group of consultants available to supplement the efforts of the Latin American research staff. Initially these consultants should be specialists in the following areas:

1. A forestry specialist with a high degree of competence in selective silviculture including the establishment of tree plantations with the aid of weed control during the establishment period.
2. A pasture management specialist with emphasis on tropical pasture experience. There is an enormous push on improved tropical pasture production throughout Latin America which has many complex problems from the standpoint of establishment and maintenance that will require specialized assistance.
3. An aquatic weed specialist with emphasis on tropical aquatics. The aquatic weed control field is highly specialized and those dealing with terrestrial weeds are seldom fully aware of the aquatic weed problems and research methods. This will require specialized consultants to aid in the assessment and development of research programs for aquatic conditions.
4. A tropical horticultural specialist. There is a rapid increase in the demand for diversified horticultural crops ranging from citrus fruit to leafy vegetables. Weed control is highly important in efficient production of these specialty crops and in many cases it appears that the basic management practices need to be changed to utilize more effective weed control methods. This would require a tropical horticultural specialist to most effectively assess the production practice changes necessary to bring about most efficient weed control.
5. Equipment and engineering consultants. As the research project develops it appears that there will be need for modification or design of special equipment to be readily adaptive to the economic and production practices available in the various regions. Consultants on equipment design and utilization should be available for this phase of the program.

6. A consultant on tropical brush control should be utilized in designing and evaluating jungle clearing programs. The University of Hawaii has done substantial preliminary research on the use of herbicides combined with fire as a means of drying jungle so it will readily burn during the dry seasons and on seeding methods to most effectively utilize the burned area. Work by the forestry department at Oregon State University in designing efficient injection equipment and chemicals to kill the re-sprouting stumps of non-killed brush species. This could be valuable as a maintenance operation to prevent the re-invasion of jungle on areas cleared by chemicals and fire. This knowledge should be utilized fully in the development of the jungle clearing program. This program should involve comparisons of the latest equipment designed for rapid jungle clearing compared to the chemical drying and burning techniques.

Agricultural Economic Department Participation

The original contract provides for part-time agricultural economics staff to work with the agronomists on this project. Although the total needs for the agricultural economic staff's assistance will become more apparent as the program develops, there are several functions that appear of initial importance. These are itemized:

1. Assistance in the design of experiments and survey projects to insure maximum utilization for economic interpretation.
2. Assistance on the interpretation of data collected on the comparative cost benefit ratios of alternative practices.
3. To evaluate the comparative benefits to the local economies of the alternative practices such as the development of new lands through more efficient jungle clearing techniques compared to increased inputs on presently available land to increase yield through adopting improved technology.
4. To project the impact on price and on international trade of large production increases that might result from shifts in efficiency between crops due to adoption of an improved weed control technology. This would include such things as increased wheat available for export from Uruguay, the impact of vastly increased cattle production by improved jungle clearing methods permitting conversion of jungle to tropical pastures in several of the tropical countries and the development of expanded rice production at the expense of pasture production on the better lands in tropical areas. There are many other illustrations that might be used to indicate some of these problems.