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1967-68

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E R R A T A

Errata in OSU.AID Weed Control Project Annual Report 1967-68

On page 18, second paragraph, third line, blank before (cansa viejo) should read *Mascagnia concima*

On page 28, in the caption under the picture, change *Manisuris sp.* to *Rotboelia exaltata.*

SECOND ANNUAL PROGRESS REPORT

"Weed Control in Less Developed Countries"

1967-68

USAID/Oregon State University

Regional Contract AID/csd-1442

OSU/AID Mimeo 68-2
Department of Farm Crops
Oregon State University
Corvallis, Oregon 97331

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FOREWORD

The following is the second annual progress report of the OSU/AID research and development contract, "Development of Weed Control in Less Developed Countries" Research is conducted within the lesser developed countries to find economic solutions to local problems. Supporting research is conducted in Oregon and Hawaii. The program is designed to coordinate the establishment of regional weed control research centers in Latin America and other areas throughout the world.

The major activity of this year has been the initiation and development of a weed control research program in Colombia and Ecuador. In addition, new staff members are currently receiving orientation and training at Oregon State University in preparation for opening new overseas research centers.

William R. Furtick
Director

SUMMARY

Annual Report 1967-68
Oregon State University/AID Contract csd-1442

DEVELOPMENT OF WEED CONTROL IN LESS DEVELOPED COUNTRIES

Introduction

The initial phase of this project is devoted to the evaluation of the importance of various weed problems in the less developed countries and placing priorities on their importance. Priorities are based on the economic impact, apparent ease of solution, and availabilities of facilities, personnel, and resources capable for solution. Major emphasis is placed on developing local research competency in the staff and institutions best suited for handling weed control research problems in the countries involved. This effort is closely coordinated with the various government agencies, universities, industries, and other agricultural organizations within each region or country. Additional emphasis is placed on developing basic practices that will have wide application to similar problem areas of the world. Publication and distribution of results to bring out maximum dissemination of information in the shortest time possible is a major objective.

The weed problems in the various less developed countries are being evaluated under the categories of (a) perennial weed problems preventing effective utilization of crop lands, (b) annual weed problems seriously reducing the production of crops, (c) woody species of humid tropical areas which encroach on cleared land, make clearing difficult, or handicap grazing, (d) woody species of arid tropics and temperate region grazing lands, (e) undesirable grass or herbaceous weeds of grazing lands, (f) poisonous weed problems of grazing lands, and (g) aquatic weed problems affecting irrigation, drainage, and navigation or fish production.

An effort is being made to collect all of the fragmented data available from various world sources within the various regions of both the developed and less developed world to bring about a complete literature review on the various important problems. Other efforts have involved development of floras which contain the most important weedy species by region that include the regional common names as well as the scientific nomenclature, development of a procedures manual for a guide to personnel in establishing the research projects, and development of a new product and practices research group that is working with the total world industries to assess the efficiency of various products and methods under the conditions of the various world production regions. This includes a program to index all known herbicides for their effective lethal dose on the most important world weeds and crops and to develop computer science for handling and retrieving the massive information being developed in the world literature and by this project.

The objectives and hypotheses to be tested by this project include:

1. To determine the validity of the hypothesis that weeds in the less developed countries prevent the effective introduction of many improved agricultural practices such as use of fertilizer.

2. To determine the effects of weeds on the total crop yield and various quality factors in major food crops.

3. To determine the validity of the assumption that a wide range of weed control practices effective in greatly increasing agricultural production in North America and Europe can be successfully introduced or adapted to the less developed countries. These factors include improved seed technology, crop rotations, fertilizer placement, timing of irrigation and water management, mechanization of weed control, use of herbicides, and increased production of forage by control of brush with chemical, mechanical, or control burn methods and the control of aquatic weeds by chemical, mechanical, and biological means.

4. The assumption will be tested that because of less highly developed agricultural technology the annual weed problem in most crops in these countries are of considerably greater magnitude than in the more developed countries. It is further assumed that improved selective annual weed control in major crops through improved tillage, chemicals, or other methods will cause a large increase in yield and quality and permit more effective utilization of fertility and other improved agricultural practices. A corollary is that new techniques can be developed which are readily adapted to the conditions of less developed countries. These might include specially designed equipment or utilization of herbicides which are of minor importance in temperate zone regions.

5. Proof will be sought for the hypothesis that improved weed control can be physically and economically accomplished within the reach of farmers and that the farmers can be taught and will use methods and that their adoption will be of economic importance to the region. This will necessitate a detailed economic study of the impact increased yields would have on the local economy including pricing, consumption, and sale of the commodities.

The initial phases of this project have been concentrated in Colombia, South America under the in-field supervision of Dr. Juan Cárdenas who has training in weed control from Oklahoma State University. He has a Ph.D. in weed control from the University of Illinois and two years of experience on the senior staff in weed control at Oregon State University. Since the University of Nebraska also had work in Colombia, this work was undertaken jointly with the program sponsored by the University of Nebraska under a contract with AID. The major effort on this research project has been conducted through the National Agriculture Institute (Instituto Colombiano Agropecuaria). This institute has research stations throughout Colombia and efforts have been made to pull together the work of other government agencies or organizations such as the Cotton Federation and various other commodity groups. The first effort was to conduct in-depth training of the young professional staff of ICA which consists of four full-time and two half-time professionals in weed control. These are located at various branch stations throughout the country.

Reconnaissance efforts have been utilized to assess the predominant weed species in the various primary food crops such as wheat, corn, rice, beans, potatoes, and in pasture. An effort has been made to evaluate all of the principal chemical and cultural weed control practices utilized on these crops in various areas of the world to determine their efficiency under the conditions of the different regions in Colombia. In addition to the major food crops, work has also been conducted on sugarcane, cotton, soybeans, sorghum, pineapple, citrus, pastures, and African oil palm.

Because of its wide spread importance specific projects have been undertaken on the control of nutsedge (*Cyperus sp.*).

A similar project has been of major importance on kikuyo grass (*Pennisetum clandestinum*) because of its importance as a perennial weed in the highland regions.

The weed control practices at the farmer level have been assessed to determine the type of practices being carried out presently by farmers and to try to measure their efficiency for weed control. These will be used as guides in determining the increase in efficiency from improved methods developed under this research project.

Summary of Preliminary Findings in Colombia

For six main crops grown in the highlands, the largest acreage of which include wheat, corn, potatoes, and beans, the losses caused by weeds average 31 percent where weed control practices are not carried out. Under the presently utilized weed control practices the average loss ranges from 10 to 15 percent.

In the semi-tropics and tropics the losses are more severe. In the Cauca Valley average weed losses of seven crops was found to be 47 percent where no weed control was practiced. In the Tolima Valley where competition for moisture is more critical, average losses due to weeds were in the order of 71 percent for corn and rice where no weed control was practiced. A conservative estimate of the crop losses due to weeds in the Cauca Valley ranged from 20 to 30 percent where current weed control practices were followed. In the Tolima Valley the losses were estimated to be 30 to 40 percent under current weed control practices and on the humid Atlantic coast weed losses under present control practices exceeded 40 percent. In addition to losses in the field the cost of production is much higher than normal and in many instances the cost is prohibitive. Considering that the value of agricultural products was 20 billion pesos, excluding coffee, and losses due to weeds are in the order of 20 percent as a conservative estimate, the country lost five billion pesos ($310 million) in 1967, directly due to weeds, under current methods of weed control. In addition, the cost of controlling weeds primarily by manual means cost in excess of $150 million for the same period. This represents a total crop loss due to weeds in agriculture of $460 million. Poisonous weeds in pastures are also taking a huge toll of livestock. A study by one of the banks indicated the loss of 15,000 head from a single species, *Mascagnia concima*. This did not measure the substantial losses caused in cattle due to the consumption of this weed by cattle that were not killed.

The losses due to weeds in non-agricultural areas is also considerable, though no estimates are currently available since work on these is of a preliminary nature. Work under this project is now concentrating on evaluating and developing satisfactory improved weed control methods for the various crops and regions and the development of an effective extension service to bring the new methods into commercial reality. Work underway in the highlands includes work in the following areas: corn, beans, wheat, barley, oats, potatoes, beets, onions, carrots, peas, pastures, kikuyo grass, ditchbank weed control, and aquatic weed control. The work undertaken during 1967 included five experiments with 22 different treatments on corn, four experiments with 22 different treatments on beans, 26 experiments in five regional trials on wheat, barley, and oats, 14 experiments with 16 treatments on potatoes, and one experiment each on beets and peas. A major program on the control of kikuyo grass was undertaken. This has already led to the preparation of a recommendations bulletin for control of kikuyo grass to be published in the fall of 1968. This new program utilizing heavily the chemical dalapon will be less than one-half as expensive as current control measures used by growers.

In sub-tropic and tropic regions extensive research trials were conducted this past year on corn, sorghum, paddy rice, dryland rice, cotton, beans, soybeans, sugarcane, tomatoes, onions, sesame, peanuts, African oil palm, bananas, citrus, coffee, pineapple, and special work on nutsedge control. Other specialized studies in this region has included pasture studies, non-crop land studies, residue studies on soil persistence of various herbicides under multi-annual cropping conditions of the tropics, herbicide compatibility studies, and general evaluation trials on various weeds and crops.

The results of this work have already indicated that many of the practices currently used in the temperate zone do not work effectively under conditions of tropics and semi-tropics. The work has further shown that new materials or modification of temperate zone practices can be developed that will adequately handle these problems on a much more efficient basis than currently used practices. Indications are that the new practices can cut the current costs of weed control by 50 percent or more. At the same time these practices improve the effectiveness of weed control and eliminate reductions in yield. Efforts are now underway to assess the economic impacts such events might have on the economy of Colombia, where food deficits require importations to supplement most of the major crops.

A supplemental project has now been established in Ecuador that parallels the Colombia project very closely. This project already has preliminary data which show a great similarity to the data obtained in Colombia.

As these data are developed it is hoped that the results of this program will not only help improve the capability of improving the world food production in some of the critical areas, but will also denote opportunities for utilization of modern weed control methods in various regions and furnish data on the importance of weed control to the economies of various areas. Such information may be instrumental in improving the budgets for weed control as a means of improving the solution of this major area of agriculture.

Current Staff and Campus Facilities

The staff of the project includes one man overseas, Dr. Juan Cárdenas, stationed in Bogotá, Colombia; three agronomists preparing on the campus for subsequent assignment to overseas locations, and a varying number of on-campus "back-up" staff members, including both administrative and technical personnel.

Dr. Cárdenas, who arrived in Bogotá in July, 1967, has responsibility for the operation of the project in Venezuela and Ecuador as well as in Colombia. He supervises weed control experiments at experiment stations at different locations in Colombia, helps train Colombian counterparts in weed control techniques, and cooperates in work being carried out by Colombian organizations.

Dr. Floyd E. Bolton, Dr. Homer M. Hepworth, and Mr. Richard R. Fine are presently on the campus preparing for assignments in Latin America. Dr. Bolton received his B.S. and M.S. degrees from Oklahoma State and his Ph.D. from Colorado State in plant genetics. He has had overseas experience in Ethiopia under the Oklahoma/AID contract where he taught agronomy and also experimented with local types of corn and coffee. Dr. Hepworth earned his B. S. and M.S. degrees from the University of Wyoming and his Ph.D. in weed control from Colorado State University. He has served in Afghanistan under a Wyoming/AID contract doing agricultural education and agronomy research. Mr. Fine has his B. S. degree from Northwest Missouri State College and his M.S. degree from the University of Missouri. He returned in late 1967 from Uruguay where he worked under the Iowa/AID contract in charge of development of a weed control research program for Uruguay. He joined this project in January, 1968.

The on-campus staff includes Dr. William R. Furtick, director; Dr. A. P. Appleby, assistant director; Mr. Lane E. Coulston, assistant to the director; Mrs. Georgena Knapp, assistant in charge of fiscal affairs; Mr. Larry C. Burrill, sub-project leader for new product evaluation; Dr. John A. Edwards, agricultural economics advisor; and John R. MacDonald, project aide.

Dr. Roman R. Romanowski of the Department of Horticulture of the University of Hawaii, who was on sabbatical leave from his institution, aided in preparation of material and organization of the program from July through December of 1967.

Administratively, the project is under the Department of Farm Crops, headed by Dr. J. Ritchie Cowan. The department is part of the School of Agriculture. Financial matters are handled through the university business office which disburses the funds assigned to the project.

The project offices have been in the Farm Crops Building, Oregon State University, but are being moved to Gilmore Annex, next door to the Farm Crops Building. These new quarters will provide space for the administrative staff, including a secretary.

REGIONAL ANNUAL REPORT FOR COLOMBIA AND ECUADOR

For the period beginning July 1, 1967
and ending July 1, 1968

Prepared

by

Juan Cardenas

SUMMARY

The Oregon State University/AID weed control program in Colombia was initiated on July 1, 1967. The following objectives set forth in the program have been accomplished: (1) Colombian research personnel have been trained in weed control research; (2) an assessment of the weed problems has been made; (3) the level of research effort was assessed and the program has been totally reorganized to fill the needs at the farmer's level; (4) efforts have been made for the establishment of an extension service in weed control, as well as for publications for the farmer.

Research has been intensified and expanded. In the highlands, research has been conducted in corn, beans, wheat, barley, oats, potatoes, beets, onions, carrots, peas, pastures, kikuyo grass, ditchbank weed control, and aquatic weed control. In addition, screening trials and regional trials have been carried out.

In the sub-tropics and tropics, weed control research has been conducted in corn, sorghum, rice (paddy and dryland), cotton, beans, soybeans, sugarcane, tomatoes, onions, sesame, peanuts, African oil palm, bananas, citrus, coffee, pineapple, nutsedge, pastures, non-crop land, residue studies, compatibility studies, yucca, hotland wheat, screening trials, regional trials, and physiological studies.

From the results obtained from two semesters of research, recommendations are now possible and will be made for a number of crops. Also, a number of technical publications will be made.

Work was also initiated in Ecuador on a cooperative basis. An agreement was reached for Ecuador to send to Colombia a counterpart for a six-month training period. Experiments in Ecuador have been conducted in corn, cacao, wheat, potatoes, and fencerows.

WEED CONTROL IN LESS DEVELOPED COUNTRIES - COLOMBIA

The following report summarizes the activities of the in-field program of the Oregon State University/AID contract "Weed Control in Less Developed Countries - Colombia" for the period July 1, 1967 to July 1, 1968.

The objectives of the program as outlined in the contract are as follows: (1) to evaluate the impact of weeds and weed control practices on the productivity of the various economically important crops; (2) to determine the level of effort in progress in evaluating losses due to weeds and to evaluate the programs in existence designed to solve these problems. Also, to evaluate the human resources and the physical facilities available for research and extension in weed control; (3) to initiate an in-depth study of the losses due to weeds and to identify the more serious weed problems; (4) to aid in the establishment of a weed control research and extension program designed to overcome the weed problems at the farmer's level of operation; (5) to determine if current levels and practices of weed control are economically feasible and, in those instances where they are not appropriate, extend research and extension efforts in order to alleviate the condition; (6) to train nationals in the basic concepts and philosophy of a sound flexible modern weed control research and extension program; (7) to assess the impact of technological, economical, and social changes brought about by the introduction of readily adaptable weed control practices.

In order to achieve these objectives, the in-field program in Colombia was divided into an initial phase and a secondary phase. The initial phase consisted of determining the needs in research, in extension, personnel, equipment, etc. in the research organizations in the country, taking into consideration the farmer's needs and the weed problems. Also, an evaluation was made of the weed problems by crop and by region and of the commonly used weed control practices.

Once the initial evaluation was made, the secondary phase of the program was initiated. The secondary phase of the program consisted in formulating a research program designed to fulfill the needs.

Initial Phase of the In-Field Program

The in-field program in Colombia was initiated on July 1, 1967 with the arrival of Dr. Juan Cárdenas at the post. The headquarters for the Colombian operation was established in Bogotá. Since the University of Nebraska also has a mission in Colombia, an agreement was made that work done in Colombia would be of a cooperative nature between Dr. Larry S. Jeffery, weed control specialist of the Nebraska Mission, and the Oregon State University weed control specialist. On this basis, Dr. Cárdenas was attached to the Nebraska Mission as an ex-officio member of the Mission. During the first few weeks after arrival, an in-depth survey was made of the human and physical resources, as well as the level of research and extension.

Research and extension efforts in Colombia have been weakened considerably in the past due to the diversity of governmental, semi-private, and private organizations performing these functions. With the diversity of entities, the

efforts have been diluted to insignificance due to the lack of communication and cooperation between these entities and to the considerable amount of time, money, and energy wasted on duplication of work. A few of the organizations involved in research and extension are: ICA (Instituto Colombiano Agropecuario), IFA (Instituto del Fomento Algodonero), Federación de Algodoneros, Federación de Cafeteros, Federación de Cacaoteros, Federación de Bananeros, Federación de Tabacaleros, Federación Nacional de Arroceros, the sugarcane industry, and FENALCE (Federación Nacional de Cereales). ICA has recently been designated by the government as the main institution for research and extension responsibilities are now being transferred to ICA. Prior to the establishment of the present policy ICA had no extension responsibilities, the extension service having been administered by the Ministry of Agriculture.

Based on the emphasis and importance ICA has been given, it was decided that this would be the agency through which the Oregon State University program would operate. At the same time, a major effort was initiated to establish a line of communication and cooperation between the different entities in order to exchange information and ideas.

The level of research and extension in the other entities varies considerably, with the best programs in weed control existing in the cotton entities. Each of the two cotton institutions has a research man in weed control and they have established a good weed control program for cotton.

Since most of the work other than the cotton research has been done through ICA, the bulk of this report will deal with this organization.

Findings

As of July, 1967, the weed control program at ICA consisted of four full-time and two half-time professionals in weed control. Research was being conducted at the following experiment stations: Tibaitatá (Bogotá), Palmira (Cali), Nataima (El Espinal), Obonuco (Pasto), Tulio Ospina and La Selva (Medellín). Research stations in which no weed control research was in progress were: Turipaná (Monteria), La Libertad (Villavicencio), and Surbatá (Tunja).

Evaluation of Each Location

TIBAITATA. (550 Ha.) serves as the headquarters for ICA and is located near Bogotá. The station serves the highlands of the eastern mountain range in which the Sabana de Bogotá and the Boyacá regions are located (2600 meters above sea level). The temperatures are cool year round with occasional frosts during the winter and summer (14°C. average temperature).

Rainfall is plentiful, although not excessive (750 mm. or 30 in.). The soils are acid and high in organic matter and, in general, fair to poorly drained. In general, full crops average five months from planting to harvest, the exception being corn, which requires 11 to 13 months. The horticultural crops vary considerably. In general, weed problems in all crops consist primarily of broadleaf weeds, among which the more agressive ones are *Chenopodium sp.* (lambsquarters), *Stellaria media* (chickweed), *Galinsoga parviflora* (galinsoga), *Rumex obtusifolius* (curled dock),

Polygonum segetum (Smartweed), *Veronica persica* (speedwell), *Amaranthus sp.* (pigweed), and *Malva sp.* (mallows). Some 20 other species occur but in general are not as aggressive; these have been identified.

Grass weeds are few, although four of them are outstanding. These are: *Avena fatua* (wild oats), *Poa annua* (annual bluegrass), and *Phalaris minor* (canary grass) as annuals, and *Pennisetum clandestinum* (kikuyo grass) as a perennial. Other grassy weed problems include *Lolium temulentum* (darnel) and *Bromus catharticus* (cheatgrass). *Avena fatua, Poa annua, Phalaris minor, Lolium temulentum,* and *Bromus catharticus* occur extensively in cereal crops. Kikuyo grass is ubiquitous in nature in the highlands and is a very aggressive stoloniferous perennial grass.

Of the broadleaf weeds *Rumex sp.* and *Polygonum sp.* are very serious weed problems particularly in poorly drained soils. Their control has been difficult due to the fact that spring wheat is grown exclusively and the conditions under which it grows are not conducive to effective and safe use of the more common and available phenoxy-type herbicides.

An interesting observation is that with the repeated use of a couple of herbicides in cereals, mainly dinitro compounds and phenoxy compounds, several resistant weed species are becoming established. Among these are *Rumex sp.* and *Veronica persica.*

The most aggressive weed in the highlands is kikuyo grass. Kikuyo grass is actually a very desirable forage grass due to its palatability, vigor, and nutritive value. However, due to its excessive vigor it is often a serious weed problem. The only method used to erradicate kikuyo grass at present is an expensive mechanical method. The method consists of disking, raking, burning, etc. The cost of this operation is quite high, ranging between 60 and 120 dollars per hectare.

There are two full-time research workers in weed control stationed at Tibaitatá and none in Surbatá. Research in weed control has been conducted previously in potatoes, corn, beans, beets, cereals, and kikuyo grass.

Physical facilities were quite satisfactory with the exception of transportation. The lack of vehicles has restricted the full development of the program. At present there is one vehicle which serves the Entomology Department, the Weed Control Department, and as the official vehicle for the director of the program.

The director of the program is Dr. Miguel Revelo (Ph.D.) and the two full-time weed control specialists at Tibaitatá are Hernando Franco and Carlos Romero, both Ingeniero Agrónomos. All full-time personnel in weed control have been with the program for only one year and are therefore lacking in experience. All full-time and half-time personnel are considered counterparts of Dr. Cárdenas and Dr. Jeffery.

PALMIRA: The experiment station at Palmira (434 Ha.) is located in the Cauca Valley near Cali at an altitude of 1000 meters above sea level. Of all the research stations it has been second in importance only to the Tibaitatá station. The climate in the Cauca Valley is nearly ideal (average temperature 24°C.) with the rainfall distribution allowing for two crops per year of crops such as corn (annual rainfall is 1000 mm. or 40 in.). The soils are fertile and in general the region is farmed by the more progressive Colombian farmers. The main crops grown in this region are sugarcane, cotton, soybeans, corn, sorghum, beans, rice, pineapple, citrus, horticultural crops, and pastures.

One full-time weed control research man, Edilberto Lagos (Ingeniero Agronomo), is located at the station. He has been with the weed control program for one year and is quite capable but still in the learning stage.

Weed control research has been extensive at this location with experiments in corn, sorghum, beans, rice, soybeans, cotton, onions, and nutsedge. Lack of adequate direction and transportation has hampered the program.

The weed problems in this region are quite varied and complex due to the nearly ideal growing conditions. Both grassy weeds and broadleaf weeds predominate. In general, the main weed problems are: *Amaranthus sp.* (pigweed), *Ipomoea sp.* (morning glory), *Cenchrus brownii* (sandbur), *Digitaria sanguinalis* (crabgrass), *Leptochloa filiformis* (sprangletop), *Echinochloa colonum* (jungle rice), *E. crusgalli* (barnyardgrass), *Paspalum dilatatum*, *Paspalum conjugatum*, *Eleusine indica* (goosegrass), *Momordica charantia*, *Jussiaea sp.*, *Cyperus sp.* (nutsedges), and *Euphorbia sp.* Of major importance is a new weed which is establishing itself in the valley. It has been tentatively identified as *Manisuris sp.* (caminadora). This weed has been reported only in the past year and it occurs primarily in rice and sugarcane fields.

Sorghum halepense (Johnson grass) and *Cynodon dactylon* (bermuda grass) occur throughout the region but are not considered serious weed pests since they are not aggressive.

NATAIMA: The experiment station Nataima (290 Ha.) is located in the Department of Tolima. It is in a valley served by the Magdalena River between the easternmost and central mountain ranges. The elevation of the region is about 400 meters above sea level, in contrast to 1000 meters for the Cauca Valley. This region receives more rainfall than the Cauca Valley but it is not well distributed (1300 mm. or 55 in.) and, in general, this area is not as fertile. Since rains are not well distributed, cropping is more hazardous. The crops grown in this region include corn, sorghum, rice, cotton, sesame, peanuts, and grapes. The region is under development for expansion of irrigation. The weed control research at this station consists of experiments in the following crops: cotton, corn, sorghum, and rice. This station has one full-time weed control man, Emiro Rojas. Its proximity and ease of access to Bogotá makes it a convenient station for experiments in the warm climates. In general, the soils of the region are sandy.

The main weed problems in this area are the same as those in the Cauca Valley. In the Tolima area due to the lack of water at certain times, competition for available water makes weeds very detrimental. It is not uncommon to note in this region, during a dry spell, many weedy fields lost entirely due to the drought which is intensified by the weed population. On the other hand, in weed-free fields the crop tolerates the drought for a longer period of time.

A highly competitive weed in this area in field crops is *Panicum maximum* (guinea grass). This weed is a very aggressive one which has a habit of growth similar to that of *Sorghum halepense* (Johnson grass).

OBONUCO: This experiment station of 564 Ha. is located in the Department of Narino in southern Colombia along the Ecuadorian border. The region is characterized by extremely mountainous, rugged terrain with most farming done on the high mountain slopes at elevations of approximately 2700 meters. The main crops of the area are the same as those of the Sabana de Bogotá and the Boyacá region. The research at this station is performed by Ing. Alonso Alvarez who is working half-time in weed control. The weed control research has been in potatoes, wheat, and barley.

TULIO OSPINA (172 Ha.) and LA SELVA (66Ha.): These stations are in the Department of Antioquia near Medellín. The region served by these stations is mountainous with most of the farming being done on mountain slopes. The Tulio Ospina experiment station is obsolete since it has been surrounded by the city of Medellín and is not representative of the region. The crops grown in this region are potatoes, cereals, corn, and beans. The region is of high altitude (1500 meters) although not as high as the Bogotá or Narino areas.

Research in weed control done in this area included potatoes, corn, and beans. At this station there is one half-time weed control specialist, C. Carmona.

TURIPANA: The experiment station of Turipaná (1780 Ha.) is the only major research station located on the Atlantic coast. It is located in the Department of Córdoba. The entire Atlantic coast is characterized by low elevations (40 meters) and is considered a low tropical area. It remains hot year round with an average temperature of 28°C. Rain occurs in two periods; hence, there are two growing seasons. The annual rainfall is 1110 mm. or 44 in. The dry season is extreme and during the rainy season rain is not well distributed. Weed growth in this area is extremely aggressive, a new weed population one month before harvest having the potential of smothering the crop. The region has the biggest potential for increased crop and livestock production, the two main factors hampering crop development being a uniform availability of water and weed control. In some areas *Cyperus sp.* has completely taken over to the extent that some farmers even fertilize it in an attempt to use it as pasture.

The main crops of the region are corn, pastures, rice, African oil palm, bananas along the coast, and cotton. A large scale effort by the government is in process to develop the area and a number of potential

crops including soybeans, sorghum, beans, citrus, and horticultural crops under experimentation.

LA LIBERTAD: The experiment station at La Libertad (1350 Ha.) is located in the Piedmont area east of the easternmost mountain range. It is not truly part of the region called Los Llanos which includes 30 million acres of prairie land. At present only the Piedmont region is being developed for intensified agriculture, although the Llanos represents a huge potential for intensified agriculture. The region is well supplied with water nine months of the year (annual rainfall 4260 mm. or 170 in.). The soils are quite leached and require a high input of fertilizers and lime for their full development. At present, the Llanos are primarily in pastures.

The Piedmont area includes the following crops: rice, cotton, and African oil palm. The weeds of the region have not yet been identified.

It should be noted that cotton is grown in four particular areas in Colombia: along the Atlantic coast, in the Piedmont region of the Llanos, in the Cauca Valley and in the Magdalena Valley. Since two crops per year are possible in each of these regions, the government has placed restrictions on the growing of cotton in each region in an effort to prevent the buildup of cotton pests. During the first half of the year (subsequently referred to as semester A) cotton growing is restricted to the Cauca and Magdalena Valleys. During the second half of the year cotton growing is restricted to the Atlantic coast and to the Piedmont region.

General Observations

In general, the physical resources at all stations was found to be adequate. The main limitation was the lack of vehicles. All work was, therefore, restricted to the confines of the experiment stations. Experimental work has not been conducted at all of the research stations due in part to a lack of manpower. The quality of the research was adequate; however, a substantial amount of effort was being wasted in obtaining information of little practical value. The program, in general, lacked any organization and research was done from season to season with no continuity or objectives in mind. Dissemination of results of any type was non-existent primarily because the concept of "research for the farmer" was missing. The quality of the personnel available was good, although lack of experience was a limiting factor.

ICA AGRONOMY EXPERIMENT STATIONS

Station	Department	Hectares	Altitude (meters)	Avg. temp. °C	Avg. rainfall (mm)
Tibaitata	Cundinamarca	550	2600	14	740
Surbata	Boyaca	74	2600	15	770
Obonuco	Narino	564	2700	13	750
Tulio Ospina	Antioquia	172	1500	21	1300
La Selva	Antioquia	66	2200	17	
Palmira	Valle	434	1000	24	1005
Nataima	Tolima	291	400	28	1320
Turipana	Cordoba	781	40	28	1112
La Libertad	Meta	350	450	26	4261

Weed Control Practices at the Farmer's Level

The Colombian farming system can be classed into three separate categories: (1) subsistence level farming, (2) farming by extensive landholding farmers, and (3) commercial farming. When considering weed control measures available to each and adaptable by each, one must consider their level of operation.

The subsistence farmer by the very nature of his classification is restricted as to input of technology. Since returns are based on the non-cost factor which is represented by his labor. Weed control practices are and will remain largely a hand labor type, i.e. use of the machete or the hoe.

The large land holder represents the other extreme and is characterized by marginal farming due to low input of money and technology per unit area. In Colombia a good number of these landholdings are either in pastures or in plantation crops such as African oil palm. The only efficient industry in this category of farming is the sugarcane industry.

The commercial farm can vary from a few hectares to several thousand hectares. Some of these farms may be as small as some subsistence farms or as large as some large landholdings. The basic difference is the input of capital and technology to exploit each unit of land to the greatest extent possible. These farms are generally characterized by their use of improved varieties, fertilizer, in some instances irrigation, insect control measures, and in many instances, weed control practices, including chemical weed control.

It must be emphasized that labor is no longer cheap in Colombia and is becoming less and less available. Under these conditions technological changes are being accepted by the commercial farmer at a rapid pace. As an example, in 1966 on the Atlantic coast, ten percent of the cotton acreage was treated with chemical herbicides. In 1967, the acreage treated with herbicides increased to 40 percent. This tremendous increase in use of herbicides was due to the increase in cost of labor, the scarcity of labor and to the more efficient, economical, and reliable weed control provided by herbicides.

At present over 90 percent of the paddy rice acreage is treated with a single commercial herbicide (propanil) and it was due to this one chemical that the rice industry in Colombia has survived. In dry land rice, farmers have been forced to seed rice in wide rows so that they can control weeds manually at great expense, since there are no commercially available herbicides for effective weed control.

However, many of the weed control practices in other crops are entirely hand operations. Climatic conditions during the rainy season make crop post-emergence mechanical weed control unreliable, particularly motorized mechanical weed control. Under climatic conditions where weeds grow so aggressively, timing of their control is critical. Studies underway indicate that in most areas and in most crops weed competition is most critical during the first 30 days of the crop. In most instances, the first weeding does not take place until after the first 30 days, at which time most of the damage has been done.

In corn, the most commonly used herbicide has been atrazine. However, because it has been the only herbicide used, resistant weed populations have been developing to the point that in some instances this excellent herbicide is no longer effective. In addition, farmers have become worried about the continued use of atrazine with a buildup in the level of toxicity of the herbicide in the soil. At this time the farmer does not have an alternate herbicide.

The same situation is occurring in the cereal grains in the highlands. The repeated use of phenoxy-type herbicides has brought about a shift in the composition of the weed population to the extent that in many fields one or two weed species have become predominant over all others, such as wild oats and *Phalaris minor*.

In addition to the common weed problems, particularly that of annual weeds, the farmer has to cope with the perennial weeds. These weeds, in contrast to annual weeds, are not as easy to control by mechanical means. Among the more aggressive weeds in this category are *Pennisetum clandestinum* (kikuyo grass), *Cyperus sp.* (nutsedge), *Ipomoea sp.* (morning glory), *Convolvulus sp.* (bindweed), and *Panicum maximum* (guinea grass). In cultivated fields where these weeds are a problem, complete crop losses are often the case. Eradication of kikuyo grass has been done manually with the cost per hectare ranging between 60 and 120 dollars in addition to losing at least one full cropping season.

In Colombia, two wheat varieties have been developed for the subtropic areas. Under experimental weed-free conditions, wheat has adapted and yielded quite well and has a great potential for development in these areas. However, one of the main limiting factors in the adoption of wheat as a crop in the warm regions is weeds. Under commercial conditions, there are no herbicides available that will be selective to wheat and control weeds. All herbicides which have been proven effective in the highlands have either been toxic to wheat under warm conditions or have failed to control the weed species in existence in the warm climates. When an appropriate herbicide is developed for wheat in the warm regions, this crop will have a better chance for success.

The problem of nutsedge in the tropics and subtropics is considerable. On the Atlantic coast, often there are 56 million tubers per hectare in the top ten inches of soil. Considering that corn is seeded at 55,000 seeds per hectare, the ratio of tubers to corn seeds is in the order of 1000:1. In many areas, corn and cotton must be replanted two or three times before a stand is obtained which will overcome the aggressiveness of the nutsedge.

In general, weed control practices are not satisfactory since they are either untimely, costly, or inadequate. Improvements in the current methods are mandatory and urgent.

Weed Control Research Programs in Existence

As mentioned previously, the main entities involved in weed control research have been the cotton institutions and ICA. Research in weed control in Colombia

has been scarce and in general not oriented to the existing weed problems with the exception of work in cotton and rice. The main effort in the establishment of modern weed control practices has been on the part of the chemical industry.

In the past ten years approximately two hundred individual experiments have been conducted. Of these, there has not been a single recommendation made to the farmer. All efforts have been aimless individual experiments with no beginning or end in mind. Research on an organized scale has not been conducted. Also, since weed control has been under the jurisdiction of the entomology programs, interest has been secondary.

Human resources for research are not sufficient but efforts are underway to expand the number of personnel available for weed control research. All of the personnel in weed control are young and inexperienced but capable. In mid-1967, the number of personnel engaged in weed control research was five. At present, there are seven, and further increase is expected.

The physical facilities available were quite good concerning land but were poor concerning equipment and transportation. The program has been severely restricted due to the lack of vehicles. Work outside of the research stations was nonexistent prior to 1968. Equipment used for weed control was totally inadequate prior to mid-1967, since the only equipment available was that which was used for entomology research.

Extension in Colombia has been nonexistent with the exception of extension in cotton and rice. Efforts are now under way to establish an efficient extension service. The introduction of new production practices in Colombian agriculture has been very slow due to the lack of extension and will continue to be slow until an efficient extension service is established.

Impact of Weeds and Weed Control Practices on the Productivity of Crops

Surveys were conducted to assess the impact of weeds on crop production in Colombia. It was found that in six of the main crops in the highlands the average loss in the field due to weeds where no weed control was practiced averaged 31 percent. Under commonly used weed control methods the losses, due to the inadequacy of the available methods, are in the order of 10 to 15 percent.

In the semi-tropics and tropics, the losses are more severe. In the Cauca Valley, averaging weed losses of seven crops, it was found that losses averaged 47 percent where no weed control was practiced. In the Tolima Valley where competition for moisture is more critical, average losses due to weeds were in the order of 71 percent for corn and rice when no weed control was practiced. A conservative estimate of crop losses due to weeds in the Cauca Valley is in the order of 20 to 30 percent where current weed control practices are followed. In the Tolima Valley, the losses are estimated to be 30 to 40 percent under current weed control practices. On the Atlantic coast weed losses exceed 40 percent.

In addition to losses in the field, the cost of production is much higher than normal; in many instances being prohibitive.

Considering that the value of agricultural products was 20 billion pesos for 1967 (1.2 billion dollars), excluding coffee, and that losses due to weeds are in the order of 20 percent (a conservative estimate), the country lost 5 billion pesos (310 million dollars) in 1967 directly due to weeds under current methods of weed control. In addition, the cost of controlling weeds, primarily by manual means, is in the order of 150 million dollars. This represents a total crop loss due to weeds in agriculture of 460 million dollars.

Poisonous weeds in pastures are also taking a huge toll in livestock. A study by Ing. B. Gomez of the Banco ganadero has shown that a single weed species, (cansa viejo) occurs in 1,050,000 hectares in an area near Barranquilla. In this area graze some 500,000 head of cattle. The loss of cattle due to poisoning by this single weed species is approximately three percent or 15,000 head of cattle. In addition, considerable losses occur in cattle which consume this weed but are not killed by it.

The losses due to weeds in non-agricultural areas is also considerable although no estimates are available. Of major importance is the establishment of large irrigation systems. Where these systems are already in operation the dissemination of weeds, particularly of nutsedge, has been considerable. Another weed problem which has developed is that of aquatic weeds within the irrigation systems and in water reservoirs.

Secondary Phase

Based on the evaluations made in the initial phase of the Oregon program, the following conclusions were drawn concerning weed control research and extension in Colombia: (1) research programs were lacking in trained personnel, (2) the research programs were not organized and lacked continuity, (3) the research programs were not oriented to farmers' needs and, in general, were far removed from actual needs, (4) the physical facilities and number of personnel were inadequate for research needs, (5) there was a total lack of extension or any other form of dissemination of information, and (6) there was a total lack of information exchange between research entities.

Based on this initial evaluation, the following objectives were set forth: (1) to train personnel, (2) to determine the extent of losses due to weeds, (3) to determine current methods of weed control used by the farmer and to assess their effectiveness, (4) to reorganize the weed control research program by a) providing maximum flexibility to the program, b) working on the basis of obtaining maximum information per experimental unit of research, and c) orient research on a cost-basis analysis, (5) organize an extension channel to disseminate weed control information to the farmer, and (6) to establish cooperative programs between the different research entities.

Training of Personnel

In order to establish the foundations for a self-sustaining research and extension program in weed control, top priority was given to the training of personnel. Training in the past year has involved not only training in weed

control research and in the past year has involved not only training in weed control research and extension, but also developing a desire in the personnel to involve themselves in their program and to bring out in them creativeness and confidence. All these objectives are being accomplished successfully at present. Colombian counterparts are always taken along during travel within Colombia and within the research stations. A total of fifteen Colombians can be considered counterparts. At first, the initiative was primarily on the part of the U.S. personnel but, as the program developed, the nationals were encouraged and guided into assuming the leadership of the program. Since this involves changing the attitudes and behavior of people, the process has not yet been completed, but the response and acceptance by the Colombians has been total. At this stage it is becoming clear to them that it is their program and that it is they who will determine how successful their program will be. In time, U.S. personnel will assume the role of advisors, rather than having a direct role in guiding the program. It has been necessary for U.S. personnel to guide the program initially as part of the training program and also to help build a solid foundation for the program. It must be emphasized that it has been the Colombian counterparts who have made the program what it is becoming. The development of the attitude of responsibility and pride in their work has been a primary objective and this is being achieved very succesfully.

To alleviate the need for personnel, efforts are being made for ICA to increase their research staff. Also, efforts are being made for ICA to establish an extension weed specialist position.

Strengthening of the Research Program

In order to maximize the amount of information per unit of research, drastic changes were suggested which were adopted by the Colombian counterparts. They were taught the type of information they should look for in order to obtain the maximum amount of information in the minimum amount of time and with the minimum amount of effort and investment. Also, they were helped to give the program direction and continuity. Every experimental unit has a definite purpose and specific information is being obtained from that unit.

Experimentation is now divided into four areas or levels of research: the preliminary phase, the secondary phase, the regional trial phase, and the phase of special weed problems. All herbicides are subjected to the preliminary phase in which selectivity to specific crops is looked for. This is very important particularly for warm climate crops, since screening of herbicides in these crops has been very limited. From this phase, selective herbicides are passed on to a secondary phase, involving a specific crop, in which crop yield is the main parameter along with degree of weed control. When compounds are found which are effective, economical, and available, they are then subjected to regional trials. Their performance in these trials determines whether or not the final recommendation can be made.

The fourth phase is one which includes specific weed problems or areas of research such as weed competition studies to determine the critical periods of weed competition, residue studies to determine the effect of continued use of specific herbicides in specific crops, such as atrazine in corn, and to study

the residual activity of herbicides where crop rotations are common, e.g. the use of atrazine in corn in a rotation program with rice or cotton. Other specific areas are nutsedge control, control of kikuyo grass, control of "caminadora", "maciega", and other grass weed problems.

To prevent or avoid possible residue problems a number of approaches are being taken, such as the use of herbicide combinations and the use of post emergence applications of herbicides at rates lower than those required for pre emergence weed control.

Development of an Efficient Extension Mechanism in Weed Control for Communication of Research Results to the Farmer

Efforts are being made to create an extension weed control specialist position within the weed control program. This specialist would be in charge primarily of regional trials and would also serve as a liaison man between general extension agents and the weed control research program. In this way a line of communications would be created between research and extension. Also, it is programmed for 1968 to initiate weed control recommendations by ICA. This will be in the form of extension publications available to everybody. In addition, seminars on the principles of weed control and field days have been held.

Since there is no weed control extension specialist at present, all work on a regional basis is presently being done in cooperation with the extension service and with the different ICA programs involved in research, such as the corn program.

Establishment of Cooperative Programs and Exchange of Information Between the Different Research Entities

At the time of initiation of the in-field program, there was no work done cooperatively and there was no exchange of information or ideas. Meetings have been held between the research institutions and cooperative programs have been established with the cotton entities, the coffee federation, the rice federation, INCORA (the agrarian reform entity), the Caja Agraria (credit entity), and the Banco Ganadero. In addition, a cooperative program has already been established with Ecuador.

From the progress made in the last six months, it is safe to say that the objectives as originally set forth are being attained. To obtain maximum cooperation between all people involved in weed control, a proposal has been made for the creation of a Colombian Weed Control Society. A preliminary meeting will be held in August, 1968 to determine the interest in the creation of such a society.

Another very important aspect of coordination has concerned the relationship between research institutes and the chemical industry. In mid-1967 the relationship was not well established and there existed a gap between these two groups. Successful efforts have been made to bring research entities and the chemical industry to work closely together in harmony.

The Research Program

During the years 1956-1966 approximately 120 experiments were conducted in weed control in Colombia. The results of these experiments were about 15 technical publications, but absolutely no weed control recommendations for the farmer. Since 1967 the number of experiments conducted has been approximately 250.

The following discussion of the research program will be divided into two areas: (1) weed control in the highlands (Tibaitatá, Obonuco, Tulio Ospina, and Surbatá) and (2) weed control in the sub-tropics (Palmira, Nataima, La Libertad) and the tropics (Monteria, Sevilla, Aracataca, and Santa Lucia).

Highlands

Since the initiation of the Oregon-Nebraska program, weed control research has been carried on in the following areas: corn, beans, wheat, barley, oats, potatoes, beets, onions, carrots, peas, pastures, kikuyo grass, ditch bank weed control, aquatic weed control, physiological studies of herbicides and growth regulators, screening trials, regional trials, and special topics.

Corn: Corn in the highlands requires 11 to 13 months to mature. Under these conditions an extended period of weed control is required. Since 1967, five experiments have been conducted in which 22 different treatments have been tested: Lorox, Afalon, diuron, Lorox plus atrazine, Afalon plus atrazine, diuron plus atrazine, atrazine, simazine, CP 50144, CP 50144 plus 2,4-D, CP 50144 plus atrazine, 2,4-D, atrazine plus sun oil (post emergence), Caldon and Premerge.

Of the 22 treatments tested, the outstanding ones to date are: atrazine, CP 50144 plus atrazine, linuron plus atrazine, and linuron. Another treatment which has shown excellent promise has been the use of atrazine plus oil as a post emergence treatment. S 6115 and NC 4780, two experimental compounds selected from Oregon, have also shown promise.

Due to the length of the growing season, recommendations are not yet possible, but recommendations are being planned for late 1968.

Beans: Since 1967 four experiments have been conducted in weed control in beans. In addition to these, three regional trials have been conducted. In these experiments 22 treatments have been tested: Caldon, Premerge, C 6313, C 3126, C 6989, Treflan, Planavin, Vernam, Prefar, amiben, and 2,4-DB. Of these, the most promising ones are 2,4-DB, C 3126, and C 6313. Amiben has also shown promise, as has Treflan. Recommendations for weed control in beans based on the three regional trials are planned for the fall of 1968. In addition, it is possible that the experimental compounds C 6313 and C 3126 may become available commercially largely due to the results obtained in these experiments.

Small grains: In the small grains, wheat, barley, and oats, a larger number of experiments have been conducted due to the diversity of the weed problems. In general, the problems fall into four categories: (1) weed control in well-drained soils, (2) weed control in poorly drained soils, (3) control of wild oats and *Phalaris minor*, and (4) susceptibility of different varieties and stages of small grains to herbicides such as 2,4-D and Tordon.

Twenty-six experiments and, in addition, five regional trials have been conducted in wheat, barley, and oats since 1967. Within these 26 experiments more than 100 treatments have been tested. Among the herbicides tested are: Afalon, Lorox, diuron, Tordon 22K, Tordon 101, Banvel D, Banvel 3, VCS 21799, 2,4-D, bromoxynil, ioxynil, R 4574, CP 50144, Caldon, Premerge, Avadex, barban, DSMA, and MSMA.

Of these compounds Afalon, Lorox, Caldon, and Premerge have been tested in regional trials and have performed quite well. For wild oats and *Phalaris minor* control, barban, MSMA, and DSMA have shown promise, and an intensified effort is being made to solve these problems. Ioxynil and bromoxynil have been shown to be excellent for the control of *Polygonum segetum* (smartweed).

Potatoes: In the past 18 months, 14 experiments have been conducted in potatoes and, in addition to these, four regional trials have been carried out. Within these experiments, more than 16 treatments have been tested. The herbicides tested have been: Premerge, Caldon, C 3126, C 6313, Lorox, Afalon, terbacil, Cotoran, Prometrine, Arenin, and Aretit. Of these compounds Premerge, Caldon, C 3126, C 6313, Afalon, and Lorox have shown promise and are being tested in regional trials.

Beets: In table beets only two experiments have been conducted since 1967. In the first experiment, none of the herbicides tested were satisfactory. A second trial is in process and herbicides selected from the Oregon trials are being tested. However, no results are available yet.

Onions and Carrots: In limited trials, the most effective compounds for weed control in carrots and onions have been Lorox and Afalon. More detailed work will be initiated in order to make specific recommendations.

Peas: Due to the relative scarcity of peas in the highlands, efforts in weed control in peas have not been intensive. One trial is in process in which the following herbicides are being tested: C 3126, C 6313, Caldon, Premerge, amiben, Treflan, and 2,4-DB. There are no results available yet.

Control of Kikuyo grass: Specific trials have been conducted on the chemical control of kikuyo grass. The results obtained have been excellent and a recommendation bulletin on the control of kikuyo grass will be published in the fall of 1968. The most effective treatment

has been dalapon. Other treatments which have had some degree of success are Amitrole and Daxtron, although the latter presents a serious problem of residue. The chemical control of kikuyo grass with dalapon is 3/4 to 1/2 as expensive as the current method and is much more effective.

Pastures: Relatively little work has been done in weed control in pastures, mainly due to the lack of time. The main problem of weeds in pastures appears to be due to lack of proper management and to the poisonous weeds, such as *Asclepias sp.*

Ditchbank and Aquatic Weed Control: Weeds in ditchbanks in the highlands are few, the predominant weed being kikuyo grass. From the work on control of kikuyo grass, recommendations are being planned for its control on ditchbanks. The present method of control is by hand, a very slow and expensive operation.

Aquatic weeds constitute a very serious problem in drainage canals in the sabana of Bogota. Preliminary experimental results indicate that paraquat is the most effective herbicide. Further work will be done in the identification of aquatic weeds and their control.

Physiological Studies: These experiments have been directed by Dr. Frank Davis of the Nebraska Mission and they involve the effect of herbicides at low rates on protein content of crops. Since these studies are underway at present, no data are yet available. Also, Dr. L. Jeffery of the Nebraska Mission is conducting further experiments on kikuyo with a new Amchem growth regulator to determine its effect on yield of wheat and barley.

Screening Trials: In order to evaluate the potential use of herbicides in all crops of the highlands, multi-crop multi-herbicide experiments were conducted in Tibaitatá for the first time in 1968. These experiments involved some 80 treatments from which information was obtained on selectivity of herbicides to highland crops. The crops tested were peas, corn, wheat, barley, oats, beans, potatoes, carrots, beets, alfalfa, and lima beans.

Regional Trials: For the first time in Colombia, weed control regional trials were conducted subjecting potential herbicides to farmers' conditions. Results have been satisfactory, although much improvement is needed. In these trials the program has cooperated with the extension service, the Caja Agraria and individual farmers. Regional trials have been conducted in wheat, potatoes, and beans.

Special Topics: Specific information on a number of problems has been totally lacking and hence work has been underway to solve many of these problems. One area of research has been in competition studies, the objective being to determine critical periods of weed competition and their effects on crop yield. Competition experiments have been conducted in beans and potatoes.

Another area of research has been directed to that of row spacing with the use of herbicides for weed control.

The Sub-tropics and Tropics

Weed control research has been conducted in Palmira and Nataima for several years. Work in Turipana (Atlantic coast) and La Libertad (Piedmont region of the Llanos Orientales) was initiated in mid-1967 with the initiation of the Oregon program.

Weed control research in these regions since 1967 has been done in the following areas: corn, sorghum, rice (paddy and dryland), cotton, beans, soybeans, sugarcane, tomatoes, onions, sesame, peanuts, African oil palm, bananas, citrus, coffee, pineapple, nutsedge, pastures, non-crop land, special studies, residue studies, compatibility studies, yucca, hotland wheat, physiological studies, screening trials, and regional trials.

Corn: A large number of experiments have been conducted in weed control in corn since 1967 (17). The only herbicide currently being used in corn is atrazine. The continued use of this herbicide has created two problems: a residue problem in view of the fact that cotton and rice are common rotation crops, and the development of atrazine-resistant weeds. In order to obtain control of these atrazine-resistant weeds, farmers have increased the rates of application, which has in turn increased the residue problem and the cost. In the Cauca Valley, farmers who rotate corn with cotton or rice have discontinued the use of herbicides in corn. In view of these two problems, research has been oriented to the development of more effective herbicides and of herbicides which create less of a residue problem.

The treatments tested include atrazine, CP 50144, C 6989, C 6313, CP 50144 plus atrazine, diuron, Lorox, Afalon, diuron plus atrazine, Lorox plus atrazine, Afalon plus atrazine, Daxtron, VCS 21799, S 6115 NC 4780, 2,4-D, C 6989 plus 2,4-D, CP 50144 plus 2,4-D, C 6313 plus C 6989, atrazine plus Sun oil (post emergence), EPTAM, and Norea. Of these compounds, the most promising treatments are: atrazine, CP 50144, CP 50144 plus atrazine, Lorox, Afalon, Lorox plus atrazine, Afalon plus atrazine, C 6989 plus 2,4-D, EPTAM, and atrazine plus Sun oil as a post emergence treatment.

Recommendations in corn will be available soon for the Palmira and Nataima regions. In the Atlantic coast and in the Llanos, more research is needed before recommendations can be made. It is important to point out that the weed problem in the Atlantic coast is severe because of the number of resistant weed species and because of the ideal conditions for weed growth. It is not uncommon that a field of corn, weed free one month prior to harvest is totally lost due to late weed growth.

Sorghum: The number of weed control experiments in sorghum since 1967 is seven. The compounds tested have been the same as those tested in corn, but unfortunately most of the compounds which have been effective in corn have been toxic to sorghum. More research is needed before recommendations can be made. *(See picture, page 26.)*

Rice: An intensive effort has been made for the development of new herbicides for paddy rice. At present, the only herbicides used in paddy rice are STAM F-34 and 2,4,5-T. Although STAM F-34 is an excellent herbicide, particularly for the control of *Echinochloa sp.*, it is incompatible with organic phosphate or chlorinated insecticides. Unfortunately, these insecticides are the most effective, and application of STAM F-34 coincides with a very critical period of insect damage. Efforts are being made to develop an effective herbicide which is compatible with the insecticides.

Ten experiments have been conducted in rice since 1967. The treatments tested have included the following compounds: STAM F-34, C 6989, Afalon, Lorox, RHC 10, 2,4-D, 2,4,5-T, MCPA, Daxtron, US 22463, C 6989 plus 2,4-D, VCS 438, VCS 21799, Glenbar, S 6115, NC 4780, R 4574, EPTAM, and Syn 100.

Of these the most promising, other than STAM F-34 are: C 6989, Syn 100, RHC 10, and R 4574. C 6989 will be commercially available soon largely due to the research efforts of the program.

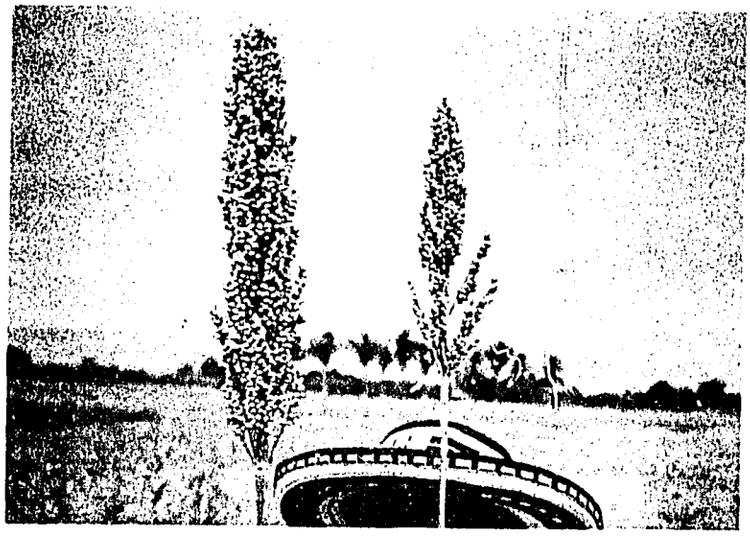
Work was initiated in 1968 for weed control in dryland rice. The weed control methods currently used are costly and inefficient. Since there is no water management to aid in the control of weeds, weed control is difficult. Farmers have been forced to seed rice in wide rows so that hand weed control is possible.

A screening trial was conducted in 1968 in Monteria, and the most promising compounds were C 6989 and RHC 10. Efforts will be intensified to develop herbicides in dryland rice. *(See pictures, pages 27-28.)*

Cotton: The weed control research in cotton has been conducted in a cooperative program between ICA and the cotton entities IFA and Fed. Algodoneros. Prior to the ICA research program in cotton, all of the work had been done by the two cotton entities. They have tested a large number of compounds and the following are being used by the farmers: Treflan, Herban, diuron, and Cotoran. In areas where cotton and corn are rotated, residue problems have occurred with Treflan. Treflan, Cotoran, and Herban have generally given excellent results. Diuron has given erratic results. Through the continued use of these herbicides, resistant populations of weeds have built up in many areas. These resistant weeds include broadleaf weeds with Treflan and, in general, *Ipomoea sp.* and *Convolvulus sp.* with all herbicides used. Work has been initiated on post emergence applications of DSMA plus diuron, Cotoran, or Herban. Results have been encouraging. Also, based on the successful use of atrazine in combination with other herbicides in corn for the control of *Ipomoea sp.*, combinations of the

SORGHUM

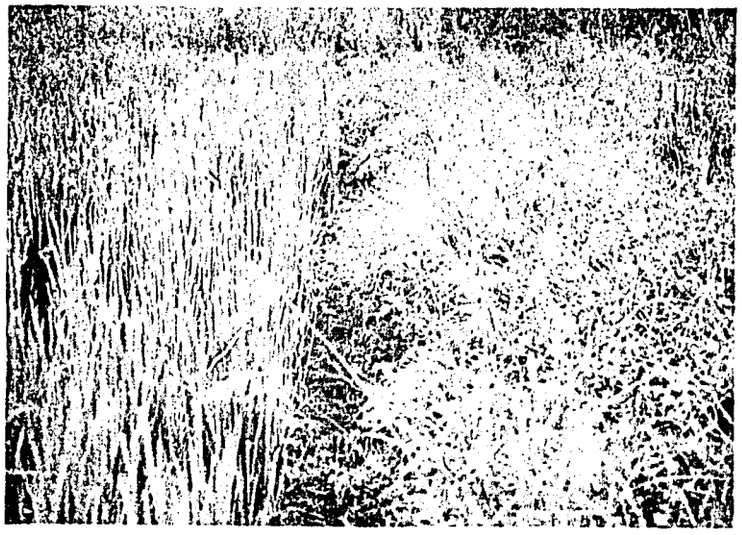
Guinea grass *(Panicum maximum)* infestation.
Nataima, Colombia



Left: Weed free
Right: Crabgrass infestation *(Digitaria sp.)*

RICE

Left: Weedy check
Right: C 6989 - 5 kg/Ha Pre-emergence
Palmira, Colombia 12/20/67



Weeded vs. weedy check
Palmira, Colombia 8/67

RICE

New perennial grass problem
(Manisuris sp.) caminadora
Palmira, Colombia 12/20/67

existing cotton herbicides and prometrine, a close analog of atrazine, have given excellent results for the control of this species.

Beans and Soybeans: The rapid increase in the acreage of beans and soybeans in the Cauca Valley has developed a critical need for efficient and economical weed control methods. With this in mind, research has been conducted in the Cauca Valley since 1967, the number of experiments totaling eight.

Compounds tested in beans and soybeans include Treflan, Planavin, CP 50144, Afalon, Lorox, amiben, Vernam, Syn 100, Prefar, C 6313, C 3126, C 6989, VCS 21799, Premerge, Caldon, and Herban. Of these, the most promising are Treflan, Planavin, CP 50144, amiben, Vernam, C 3126, C 6313, and Herban. Recommendations are expected for early 1969.

Sugarcane: All of the research on sugarcane has been concentrated in the Cauca Valley since most of the intensified cropping is practiced in this region. Since 1967, three experiments have been conducted and the treatments that have been tested are: diuron, diuron plus atrazine, atrazine, Daxtron, Ametryne, Ametryne plus atrazine plus 2,4-D, Herban, Herban plus 2,4-D, TCA, Dalapon, terbacil, bromacil, 2,4-D, CP 50144, CP 50144 plus atrazine, and TCA plus 2,4-D.

Of these treatments, the following show promise: diuron, diuron plus atrazine, Ametryne, Ametryne plus atrazine plus 2,4-D, Herban plus 2,4-D, terbacil, and CP 50144 plus atrazine. Recommendations will be made in 1969.

Tomatoes and Onions: Experiments in tomatoes are being conducted in Santa Lucia on the Atlantic coast in cooperation with INCORA. This work was initiated in 1968, so results are not yet available. One experiment was conducted in Palmira in onions in 1967; among the outstanding herbicides were Dacthal, two CIBA compounds, Afalon, and Lorox. Further work must be done before recommendations can be made.

Sesame and Peanuts: Cooperative research was initiated with IFA in 1968 with two experiments in the Tolima Valley. At this time it is too early to draw conclusions from these experiments.

Plantation Crops (African oil palm, bananas, citrus, coffee, and pineapple): Prior to mid-1967 no weed control research had been done in these crops. In late 1967, work was initiated in African oil palm and this program became a cooperative program with IFA in 1968. Weed control research in African oil palm is divided into four areas: (1) establishment of the young palms, (2) establishment of a cover crop such as *Pueraria javanica*, (3) weed control around the base of the established palms, and (4) weed control for paths throughout the plantation for easy access to the palms at harvest. Since these experiments are underway, no results are yet available.

Weed problem in oil palm

AFRICAN OIL PALM

Legume cover crop in oil palm

In bananas, an intensified effort has been made since mid-1967 so that recommendations can be made by late 1968. The best treatments have been diuron, diuron plus atrazine, and paraquat.

The work on weed control in coffee was initiated only in April, no results are yet available.

The most advanced work has been in citrus. Experiments were conducted in late 1967 and in 1968. The most outstanding treatments have been diuron, diuron plus atrazine, terbacil, Herban plus MSMA, and paraquat. The treatments which have been tested in citrus are now being tested in coffee. These include MSMA, DSMA, Simazine, Dalapon, amitrol, and casoron, in addition to the herbicides mentioned previously. Recommendations will be made by late 1968.

In pineapple, the following compounds have been tested: terbacil, bromacil, diuron, atrazine, diuron plus atrazine, ametryne, and Herban. All treatments have given good results with terbacil and diuron showing the most promise. Bromacil followed by terbacil has been the most effective treatment where nutsedge has been a problem.

Nutsedge: The number one weed problem in the sub-tropics and tropics is nutsedge *(Cyperus sp.)*. The least serious nutsedge problem in Colombia is found in the Tolima Valley where nutsedge apparently does not form bulbs, probably due to climatic conditions. It does reproduce by seed and, if not controlled, can constitute a serious problem in rice fields. In the Cauca Valley, the nutsedge problem is more severe, the infestation in some fields being 11 million bulbs for a 30-cm. hectare. The germination potential for these nuts is approxi-

mately 72 percent, thus of the 11 million nuts there can be eight million nutsedge plants per hectare.

In the Atlantic coast, the problem is most severe. As shown in the table below, the population of bulbs in the soil (30-cm. hectare) is astronomical.

Nutsedge Bulb Population in Turipana

Sample depth (cm.)	Avg. no. bulbs/hectare (millions)	Range (millions) Min.	Max.
0-10	29.7	21.9	54.2
10-20	20.0	5.0	35.3
20-30	5.9	1.2	10.3
Total	55.6	28.1	99.8

If one considers that corn is planted at a rate of 50,000 plants per hectare, the ratio of bulbs to corn seeds is 1000:1.

In view of the severity of the problem an intensified effort is underway to (1) determine its seriousness as a weed in crops, including the extent and critical periods of competition, (2) chemical weed control of nutsedge in corn, beans, rice, and cotton, (3) methods to eradicate the nutsedge, (4) screen new compounds for the control and eradication of nutsedge, and (5) physiological studies of nutsedge in order to know the weed better.

Six experiments in nutsedge control were begun in mid-1967 and 11 additional ones are being conducted in 1968. Most of the work has been done in Turipana where the problem is most severe. Work has also been done at Palmira and will be intensified there. EPTAM has given the most outstanding control of nutsedge in corn. In beans and cotton, Vernam has given excellent results and in rice, R 4574 has been outstanding. Other treatments being evaluated for corn are chemical seedbed preprataions using 2,4-D, MSMA, DSMA, and paraquat. Results, although preliminary, are encouraging.

In the program for eradication of nutsedge, a number of chemical treatments and combinations of compounds with mechanical cultivation are being conducted. Excellent results have been obtained in decreasing the nutsedge population with repeated applications of the following compounds: 2,4-D, amitrole, MSMA, DSMA and combinations of these along with disking.

In the screening of other chemicals, dicamba and dicamba plus 2,4-D have given good results in the control of nutsedge. Recommendations are expected to be made by early 1969.

Pastures: In the sub-tropics and tropics, the main agricultural enterprise is livestock and associated with this enterprise are millions of hectares of pasture. Unfortunately, the large majority of these pastures are producing at minimum levels due to poor management. In consequence, the weed problem is severe, in many cases almost totally impairing the use of pastures. There are two types of severe problems; one is that of broadleaf weeds, brush and poisonous weeds and the other is that of undesirable weedy grasses. The farmer has tools available to solve the first problem, although research is lacking in this area. Work for the control of these weeds is in process in Turipana and La Libertad.

Very little work on the control of weedy grasses in pastures has been done anywhere in the world. Work is being initiated in Turipana to screen selective grass weed killers. This is the area in which the most work needs to be done in weed control in pastures.

To date, five experiments have been conducted in broadleaf weed control in pastures.

Non-agricultural Land: A large amount of money and time is spent on farms controlling weeds along fencerows and on ditchbanks. Experiments have been conducted and recommendations will be made for the fall of 1968 on fencerow weed control. The problem in fencerow weed control is that it is most needed when labor is most needed for crop production. The following treatments have been tested: diuron, atrazine, diuron plus atrazine, simazine, TCA, Dalapon, diuron plus Tordon, terbacil, bromacil, Daxtron, Amitrole, and diuron plus 2,4-D. The best results have been obtained with diuron, diuron plus atrazine, diuron plus Tordon, and bromacil. A total of six experiments have been conducted on fencerow weed control. On ditchbank weed control, two experiments have been conducted, although a total re-evaluation of this program is in process since erosion problems have been encountered. The new approach will be the establishment and maintenance of *Cynodon dactylon*(Bermuda grass).

Special Studies: Work has been in progress on weed competition studies in the following crops: rice (2), cotton (2), sorghum (3), corn (4), beans (1), and soybeans (1). The purpose of these experiments is to determine the extent of losses due to weeds and the critical periods of weed competition. Excellent results have been obtained and publications will be in press by late 1968.

Residue Studies: The increasing importance of the continued use of herbicides such as atrazine in corn and Treflan in cotton have begun to create problems for the farmer. Studies are under way to determine their persistence and to find solutions to these problems.

Compatibility Studies: The knowledge of the compatibility of herbicides and insecticides is nil with the exception of STAM F-34 in rice. At present, work is being planned for studies of compatibility between C 6989, the most promising new rice herbicide, and the commonly used insecticides.

Yucca: Work was initiated for weed control in yucca and approximately 40 treatments were screened. Of these, about 10 treatments showed promise and will be included in secondary trials.

Physiological Studies: Dr. F. S. Davis of the Nebraska Mission is conducting physiological studies for the sub-tropics and tropics similar to the ones described for the highlands (effect of herbicides on protein content of crops, using herbicides at rates much lower than herbicidal rates). Also, physiological studies have been planned for work in nutsedge.

Screening Trials: Information on the selectivity of commercially available herbicides and experimental herbicides for sub-tropical and tropical crops is quite limited. In view of this, screening trials have been conducted in Palmira and in Nataima. The objective of these trials is to determine selectivity of chemical compounds to crops of the region. In Palmira the screening trial was carried out with beans, soybeans, tomatoes, corn, sorghum, cotton, rice, hotland wheat, sesame, peanuts, crotolaria, paddy rice, and yucca, and a screening trial in sugarcane is being planned.

The screening trial presently being conducted in Nataima includes the crops tested in Palmira and, in addition, tobacco, tomatoes, and three of the predominant weed species of the Tolima Valley. Eighty treatments were tested in Palmira and 90 treatments are being tested in Nataima. Results will be distributed internally and to Oregon since this type of information is preliminary.

Regional Trials: Regional trials in corn (2) and rice (3) were conducted for the first time in the Tolima Valley.

Hotland Wheat: Two ICA varieties have been developed for the Valle-Tolima areas, but to date a number of complicating factors have not allowed wheat to be grown commercially. One of the most important of these factors is that of weeds. Since wheat in the sub-tropics is a relatively new concept, very little work has been done on this subject. In mid-1967, the research in hotland wheat was being done by the Caja Agraria. Up to that time, no herbicides had shown promise for weed control in wheat. Upon initiation of the Oregon program cooperative work was initiated between Caja Agraria and ICA. In the second semester of 1967 work was continued and 25 treatments were tested, including the best treatments obtained for wheat in the highlands. In this semester, it was found that the most effective treatments for weed control in wheat in the highlands were either ineffective in controlling weeds or were toxic to the wheat. Based on the

negative results obtained an intensified effort was initiated in the first semester of 1968. A total of four experiments are being conducted during this semester involving 35 treatments. These include CP 50144, Caldon, Premerge, 2,4-D, Tordon, diuron, Lorox, Afalon, C 6989, MSMA, DSMA, Daxtron, linuron plus 2,4-D, C 6989 plus dicamba, DNBP plus picloram, CP 50144 plus 2,4-D, bromoxynil, ioxynil, SA 6602, SA 6706, prometryne, UC 22463. To date the most promising treatments appear to be DSMA, C 6989, and prometryne. More work must be done before posititive answers can be found, but at present it appears that solutions to the problem are near at hand. The treatments selected have performed well in these trials and recommendations can now be made. More regional trials were not possible because of the lack of personnel, extensionists, and transportation.

Regional trials will be established in the Cauca Valley during Semester B, 1968.

Other Activities: During the second semester of 1967, Dr. J. Cárdenas taught a course in the new Graduate Training Program at ICA entitled "Growth and Development". In 1968, second semester, Dr. J. Cárdenas, Dr. F. S. Davis, and several Colombian counterparts will teach the undergraduate weed control course at the National University.

In 1968, a seminar was presented during INCORA's International Irrigation short course in ditchbank and aquatic weed control. Attending the meeting were representatives of five countries. Another seminar of this type will be presented in July, 1968.

The following publications are planned for 1968: "Economic Losses Due to Weeds in Colombia", "Weeds Identification Manual for the Highlands", "Herbicide Combinations", weed control recommendations for corn (highlands), corn (sub-tropics), potatoes, beans, wheat, oats, barley, soybeans, rice, sugarcane, bananas, control of kikuyo grass, and critical periods of weed competition for corn, sorghum, cotton, citrus, and pineapple. Also planned for internal publication are the results of experimental research for 1967 B, 1968 A, and 1968 B as well as the results of the screening trials conducted in 1968 A.

Efforts were initiated for the establishment of a Colombian Weed Control Society. The purpose of this society will be to bring together all of the weed control research and extension personnel together with industry and other research and government entities in order to establish a channel for the formal exchange of information and ideas. A preliminary meeting will be held in August and the first formal meeting is planned for January, 1969.

In working with the National University and ICA's recently formed graduate school, Dr. Cárdenas is currently directing eight thesis problems.

In the fall of 1967, a paper was presented in Venezuela on the nature of the Oregon State University/AID Regional Program "Weed Control in Less Developed Countries" at the ALAF (Associacion Latino Americana de Fitotecnia). In February, 1968, three papers were presented at the New Orleans meetings of the Weed Science Society of America: "Weed Control in Rice," "Weed Control in Less Developed Countries--Colombia," and "The Status of Weed Control Teaching in Latin American Universities".

WEED CONTROL IN LESS DEVELOPED COUNTRIES--ECUADOR

The OSU/AID program in Ecuador was established in December, 1967. Three of the four research stations in Ecuador were visited and work was initiated on a cooperative basis in all three stations. In the highlands (Santa Catalina) experiments were set up in wheat and potatoes. In the tropics experiments were set up in corn (2), cacao (1), and fencerows (1).

The most important achievement was the agreement with INIAP (Instituto Nacional de Investigaciones Agro-Pecuarias--of Ecuador) that a counterpart be sent to Colombia for a six-month training period. The counterpart arrived in June, 1968, and is currently undergoing intensive training in weed control. Upon his return to Ecuador, he will head a new weed control program.

Excellent results in the experiments established in Ecuador have been obtained for corn and cacao. The results obtained in corn are the same as those obtained in Colombia indicating that a cooperative program between Ecuador and Colombia could be very rewarding to both countries.

NEW HERBICIDE EVALUATION PROJECT

The task of finding methods to control undesirable vegetation in the many crops grown throughout the world is formidable. All indications point to the use of herbicides as the most effective and efficient method to obtain weed-free crop production. This requires the availability to producers of a supply of safe, effective, and economical herbicides. A rapid and effective method of evaluating the ever-increasing numbers of potential weed killers from the world's chemical industry is necessary to provide the information needed to accomplish these objectives.

The purpose of the new herbicide evaluation program at Oregon State University is to bring together, from the entire world chemical industry, all of the new herbicides while still in an early stage of testing and to compare these herbicides under as many conditions and on as many crops and weeds as needed to assess their potential adequately.

Under present conditions it will take five years or longer from the time a chemical first is considered to show promise of becoming a commercial herbicide until it is available on the market. It is often possible to reduce this time by a year or more by preliminary testing of a material under field conditions during the winter months. This early testing gives company management time to prepare for full testing of a promising material during the growing season.

To provide the winter testing under field conditions a cooperative program is underway with the University of Hawaii, School of Tropical Agriculture. In January of each year most of the world chemical companies submit potential new herbicides to be tested under field conditions on the Island of Kauai, Hawaii. The new chemicals are evaluated on their safety to crop species and effectiveness on a wide range of weeds. By March the information is in the hands of the chemical companies and other research people to allow time for preparation for full scale field testing where warranted.

Researchers at the University of Hawaii carry out immediate follow-up research work on those materials which appear to be promising for solving problems pertinent to their conditions. In March plans are made by personnel of this project to evaluate the most promising compounds from the Hawaii test in a series of trials on individual crops under actual production conditions in Oregon. In addition a multi-crop evaluation trial similar to the one in Hawaii is conducted during the spring, summer, and fall seasons. The spring trial is grown under warm days and cold nights with daily light rainfall a common occurrence. In the summer the temperatures are high and irrigation is necessary to maintain crop growth. In the fall cold nights and mornings and warm afternoons are normal and heavy rains are not uncommon. The crops and weeds grown for each trial are changed in an effort to have at least one of the trials during a year closely approximate growing conditions in some of the major crop production areas of the world.

All of the chemicals from the Hawaii trial which appear to be promising are included in a test in Oregon to determine how long they remain in the soil.

Beginning in 1969 all active compounds will be tested on a series of well-established perennial crops and weeds.

The most promising compounds in the Hawaii and Oregon tests are sent to Dr. Juan Cardenas in Bogota, Colombia who, as an in-field member of this project, is responsible for testing the materials in a series of multi-crop and mono-crop trials in Colombia, Ecuador, and Venezuela.

A cooperative program has been underway in Chile, South America, for a number of years. Chilean research workers trained at Oregon State University do field testing of the more advanced experimental compounds during the North American winter months under the temperate conditions in Chile.

The project is currently cooperating with 48 different chemical companies from the United States, England, Germany, Switzerland, and Japan.

In the five separate new compound evaluation trials established in the period of March, 1967 through June, 1968, 157 different compounds were tested. This represents compounds from 33 chemical companies. A total of 32 crops and 16 weeds were used to evaluate the chemicals. Many of the chemicals tested during this period have been discontinued since, while others have been extensively tested in Hawaii, Oregon, Colombia, and Chile, South America.

A number of products field tested for the first time in this program appear highly promising for solving major weed problems.

CROPS USED TO EVALUATE NEW HERBICIDES

alfalfa	*Medicago sativa*
birdsfoot trefoil	*Lotus corniculatus*
white clover	*Trifolium repens*
red clover	*Trifolium pratense*
onions	*Allium cepa*
spinach	*Spinacea oleracea*
carrots	*Daucus carota*
lettuce	*Lactuca sativa*
cabbage	*Brassica oleracea*
tomatoes	*Lycopersicon esculentum*
cucumbers	*Cucumis sativus*
cotton	*Gossypium barbadense*
oats	*Avena sativa*
wheat	*Triticum vulgare*
barley	*Hordeum vulgare*
safflower	*Carthamus tinctorius*
rice	*Oryza sativa*
green beans	*Phaseolus vulgaris*
soybeans	*Glycine max*
peas	*Pisum sativum*
sunflower	*Helianthus annuus*
sweet corn	*Zea mays*
sugarbeets	*Beta vulgaris*
rape	*Brassica napus*
peanuts	*Arachis hypogeae*

lentils	*Lentilla lens*
flax	*Linum usifatissium*
orchardgrass	*Dactylis glomerata*
broccoli	*Brassica oleracea*
vetch	*Vicia sativa*
Sudangrass	*Sorghum vulgare*
rye	*Secale cereale*

WEEDS USED TO EVALUATE NEW HERBICIDES

annual ryegrass	*Lolium multiflorum*
crabgrass	*Digitaria sp.*
wiregrass	*Eleusine indica*
Amaranthus	*Amaranthus spp.*
tarweed	*Cuphea carthagenensis*
green kyllinga	*Cyperus brevefolius*
Floras paint brush	*Emilia coccinea*
barnyardgrass	*Echinochloa crusgalli*
purslane	*Portulaca oleracea*
downy brome	*Bromus tectorum*
wild oats	*Avena fatua*
wild mustard	*Brassica campestris*
green foxtail	*Setaria viridis*
lambsquarters	*Chenopodium album*
wild snapdragon	*Antirrhumum orontium*
knotweed	*Polygonum aviculare*

TRUCKS AND EQUIPMENT

After more than 10 years of research and actual field experience the staff of the weed control project at Oregon State University has compiled a list of supplies and equipment which allow the field researcher to be fast, accurate, and safe in his work. Very few changes in the basic list are required to equip a man for work abroad. Generally, the changes consist of increasing the supply of expendable items. Certain tools for building and repairing equipment were added because of the uncertainty of having this work done in other countries.

Trucks

Each person going outside the United States to do field research will be supplied with a pickup truck. Reliable transportation, free from conflicting demands, is essential to provide the mobility which is vital to a successful field program. However, the trucks which have been prepared for field use are equipped to provide much more than transportation. They have been patterned after trucks already in use by the Oregon State staff to provide a self-contained, efficient, and convenient mobile unit. Each unit is designed to support the researcher in establishing, spraying, maintaining, and evaluating field plots.

The trucks are heavy-duty pickups with four-wheel drive and four-speed transmissions. They are fitted with a metal canopy to provide protection for all of the field equipment. The basic equipment consists of an eighty gallon pressurized water system and a small air compressor powered by a gasoline engine. Storage space is provided by three specially constructed boxes, permanently mounted and located in otherwise wasted space.

Spraying

The basic unit for the actual spraying application is a single-wheeled bicycle-type plot sprayer with a ten and eight foot boom and a one meter boom. Each sprayer is equipped with a four gallon spray can for large plots and a one-half or one gallon can for small plots. A small hand sprayer is also provided to be used where the larger sprayer is not practical. Miscellaneous beakers, pipettes, and graduated cylinders are carried in the trucks at all times to assure rapid and accurate measuring and mixing of chemicals.

Truck equipment

- 12 gallon gas motor air compressor
- two 40 gallon round water storage tanks
- one ax
- one shovel
- one 25-foot tow chain
- three wooden storage boxes

Spraying equipment

- one single-wheeled, compressed air plot sprayer
- one four-gallon spray can
- one one gallon spray can
- one ten-foot boom
- one eight-foot boom
- one one meter boom
- one one gallon hand sprayer with six-foot boom

Measuring and mixing

four one-half gallon stainless steel pitchers
four 150 ml polyethylene beakers
three 10 ml polyethylene pipettes and bulb
two 25 ml polyethylene graduated cylinders
two 100 ml polyethylene graduated cylinders
one Harverd trip balance with pan
four one gallon polyethylene jugs
50 polyethylene 10 and 25 cc syringes

Miscellaneous equipment

two 300 meter steel tapes and reels
two two-pound hammers
one case lumber crayon
two one gallon jerry cans for gasoline
three one pint wash bottles
two soil thermometers
two air thermometers
two wind gauges
one 25-foot garden hose and nozzle
1,000 chemical envelopes

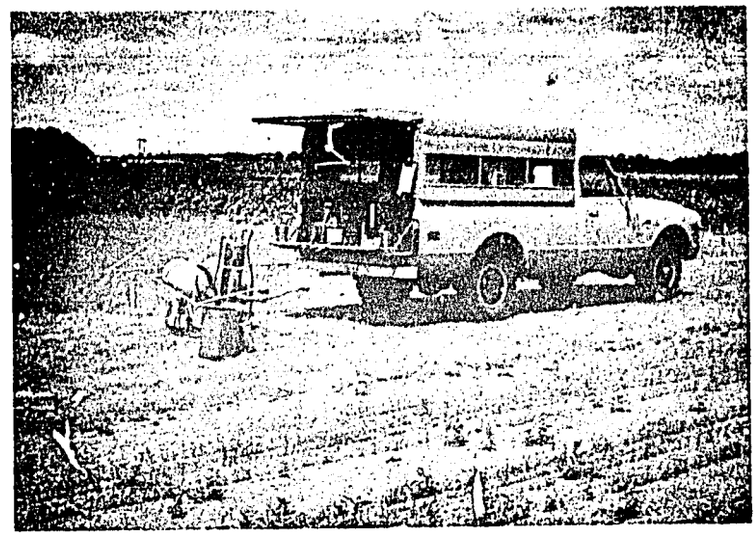
Safety equipment and supplies

36 pairs rubber gloves
safety glasses
first aid kit
protective hand cream
dry chemical fire extinguisher
two cell flashlight

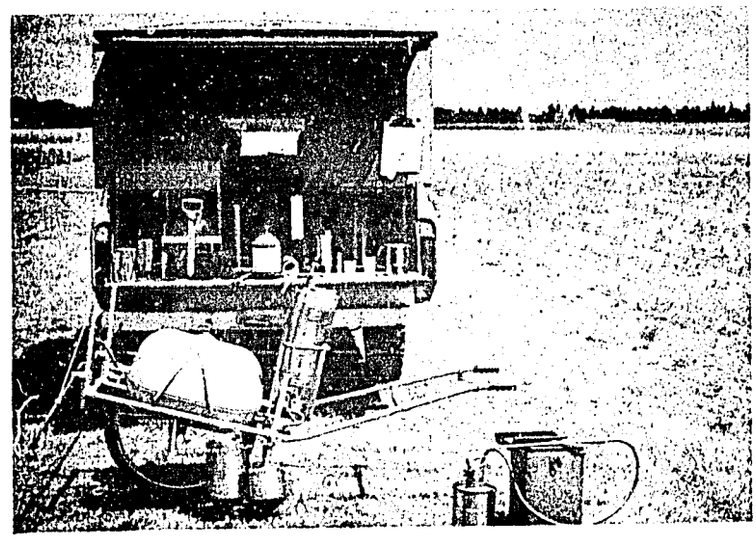
Hand tools

A complete set of hand tools is provided to allow the researcher to build or repair most equipment used in the field.

TRUCKS AND EQUIPMENT

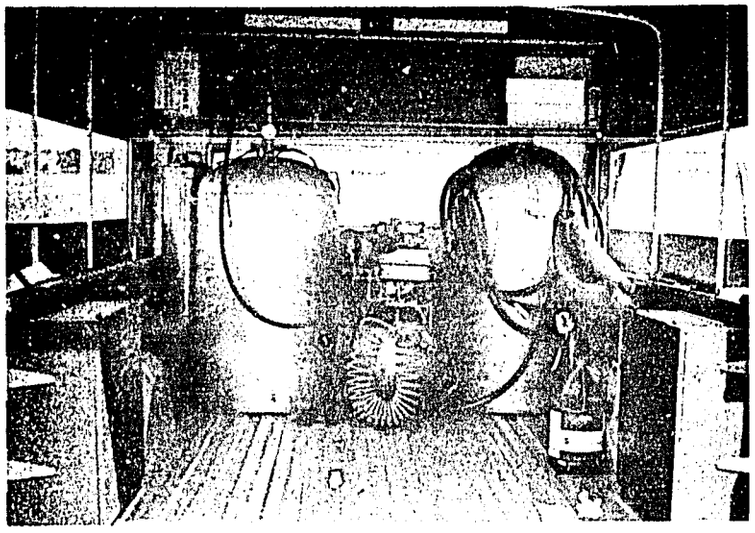


3/4 ton 4-wheel drive truck with sprayer
and other field equipment.

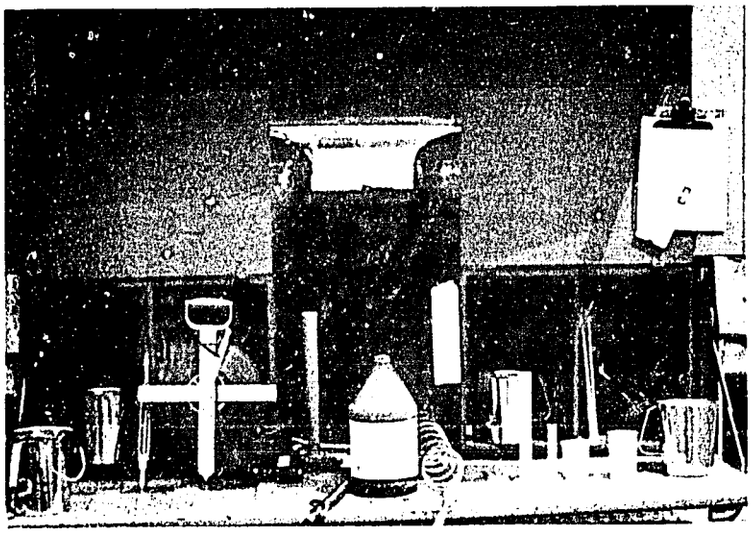


Truck prepared for field spraying.
Hand sprayer, wheel sprayer and extra spray tanks.

TRUCKS AND EQUIPMENT



Inside of pickup truck showing water tanks, air compressors and storage areas.



Durable measuring and mixing containers, air hose from compressor and water hose from tanks.

PREPARATION FOR IN-FIELD ASSIGNMENTS

Introduction

In preparation for assignments in Latin America a broad on-campus training program was designed for the staff arriving in January and March of this year. The training period was planned to give the staff additional training in Spanish and to update them on current weed control experimentation practices. The training program provided orientation and contacts with Oregon State University personnel, field tours, and additional contacts with other university and industry professional personnel in weed control.

Spanish Language Instruction

The Modern Language Department of Oregon State University cooperated in providing a three-month intensive Spanish training course for the staff members and wives preparing for in-field assignment. This group included four staff members and three wives.

The first phase of the language training, under the direction of Mr. Robert Kiekel, began on March 1, 1968. A second phase program, initiated in June, will continue through July and August. This program will continue in Spanish and concentrate on applied linguistic principles in learning a foreign language.

OSU Campus Workshop

This workshop was provided for the AID on-campus and future off-campus staff to give a thorough orientation on the involvement or potential involvement of key departments at Oregon State University. The workshop was conducted January 25, 26, and 29. Departments cooperating were Agricultural Economics, Agricultural Chemistry, Forestry, and Geography. Also, a session was included on experimental equipment provided by a local firm, Mater Machine Works.

Those responsible for the presentations from cooperating departments were: Dr. Emery Castle, Agricultural Economics; Dr. Virgil Freed, Agricultural Chemistry; Dr. Michael Newton, Forestry; and Dr. Granville Jensen, Geography. The programs presented were given by various staff members within each department. All sessions were open and attended by graduate students, staff, and other interested persons.

First Annual Workshop

Under AID contract csd-1442 provision is made for an annual work conference of the staff to review progress and make detailed plans for coordinating future work under this project. Under the project proposal these conferences were to be held in Latin America and were to include the participation of the in-field staff and the resident staff at Corvallis.

Since most of the staff for the overseas program are not yet in Latin America, the conference was transferred from Latin America to New Orleans, Louisiana for the first annual workshop which was held directly following the on-campus workshop and orientation, February 1-4. This workshop was held prior to and including the meetings of the Weed Science Society of America. The timing of this meeting made possible the services of many industrial representatives and members of the Advisory Committee. The agenda for this workshop was as follows:

1. Review of objectives, procedures, and progress.

2. In-depth report of the in-field project in Colombia.

3. Review of budgets, operating procedures, and other administrative details.

4. Review of reporting procedures.

5. Review of Corvallis program of research in support of the in-field program.

   a. Evaluation of new herbicides, procedures, and equipment.
   b. Review of latest weed control results in temperate zone crops.
   c. Review of latest procedures and results for weed control in tropical crops.
   d. Weed loss trials.

6. Review of the FAO project on crop loss data as it applied to AID contract csd-1442.

7. Discussion on collection of survey and economic data.

8. Industry review. The international representatives of each of the major chemical and equipment industries, dealing with weed control products in Latin America, were asked to outline their programs in Latin America and discuss ways in which their interests could be coordinated with AID project csd-1442.

9. Meeting of the Advisory Committee.

Professional Meetings and Tours

Efforts have been made to establish and acquaint the staff with individuals in professional circles and organizations involved in weed control.

Several professional meetings were attended. The staff also participated in field tours acquainting themselves with the agriculture and weed control practices of Oregon and California.

Meetings attended by Dr. W. R. Furtick and/or staff were:

1. FAO Symposium on Crop Losses - Rome, Italy - October 1967
2. Oregon Weed Conference - Salem, Oregon - November 1967
3. California Weed Conference - Sacramento, California - January 1968
4. Weed Science Society of America - New Orleans, Louisiana - February 1968
5. Western Weed Science Conference - Boise, Idaho - March 1968

Worthy of particular mention is the attendance at the FAO Symposium by Dr. Furtick. At this meeting he was appointed to a committee for the evaluation of crop losses due to weeds and has submitted a proposal for the assessment of the impact of this problem throughout the world.

The Weed Science Society of America program centered around weed control and the world food problem. A special section of these meetings was devoted to presentations on Latin American weed control. Dr. Juan Cardenas, of the project, participated in the organization of this program and helped arrange for the attendance and presentation of papers by his Colombian counterpart.

Field Tours Attended

1. Washington Weed Tour - Yakima, Washington - August 1967
2. Eastern Oregon and Idaho Sugar Beet Area - March 1968
3. Eastern Oregon Weed Tour - May 2-3, 1968
4. California Weed Tour - May 1968
5. Western Oregon Weed Tour - June 11-13, 1968

Special Seminar Series

During Spring quarter, weekly seminars were held for staff and graduate students in weed control. Topics were selected to provide additional information and to acquaint the participants in developments in herbicide practices. Several field tours were conducted to review work being carried out in weed control.

Special Projects

Throughout the year special projects have been undertaken to support and increase the effectiveness of the project. Projects of special importance to the technical development of the project are covered briefly in the following section.

Projects Completed

1. Translation of the weed research work in Chile.

2. Re-organization of files and handling of business affairs.

3. Editing of in-field reports and establishment of guidelines.

4. Survey of literature for kikuyo grass control methods.

5. Establishment of procedures for obtaining recommendations from:

   a. U.S. Experiment Station
   b. Europe-European Weed Council Report
   c. Industry

6. Weed Research Methods Manual.

7. Literature review on weed losses.

8. Distribution of Weed Lists of Latin America.

9. Mailing lists for industry, universities, and international weed workers.

Projects Being Developed

1. Herbicide and weed susceptibility chart.

2. International Weed Control Handbook.

3. Survey of equipment industry.

4. Translation of Weed Research Methods Manual (AID/OSU 68-1) into Spanish.

5. Slide classification scheme.

6. Administrative procedures manual.

SPECIAL PROJECTS COMPLETED

Translation of Weed Research Work in Chile

The Fourth Annual Report of the OSU Cooperative Chilean Herbicide Research project was translated from Spanish into English by Mrs. Georgena Knapp, the project assistant.

This report is on research conducted at the Canillanca Experiment Station in Chile under the direction of William R. Furtick, Hernan Lopez, Temuco, Chile, and Jenaro del Pozo, Chillan, Chile.

Survey of Literature for Kikuyo Grass *(Pennisetum clandestinum)* Control Methods

Information compiled by Dr. Romanowski on the latest thoughts on the control of kikuyo grass for the use by Dr. Cardenas in Colombia.

Weed Research Methods Manual for Establishing New Programs, OSU/AID Mimeo 68-1

Drs. Romanowski and Furtick cooperated on the development of this publication. This manual was distributed on a manuscript basis and is being considered for publication.

Literature Review on Weed Losses

A literature review was conducted on all available literature pertaining to losses due to weeds. An effort was made to locate material particularly relevant to economic losses. In essence, the studies conducted have dealt with estimations of crop yield losses and the cost of chemical application.

Distribution of Weed Lists of Latin America

Following the completion of the Weed Lists for Latin America, they were circulated on a worldwide basis. Copies were distributed through AID/Washington to overseas missions. Many were distributed to weed workers in Latin America.

Mailing Lists

In anticipation of the necessity for a wider and more complete coverage of industry, university, and international weed workers, efforts have been made to expand and organize mailing lists. As the project expands its work areas, it is vital to maintain contact with other programs as well as to make information available from this project.

Administration Manual for AID Project

In addition to the General Provisions provided by AID, it was found desirable to develop an administrative procedures manual. This was designed with the intention of providing a more knowledgeable and efficient orientation and guide for project staff.

The manual as developed includes various topics of special interest taken from the general providions and university regulations. This manual serves to outline and summarize important information while serving as a quick reference to other sources for more detailed explanations. Also, information regarding personal matters not specifically given in other publications is included.

The following is the outline of content:

1. Preparation for in-field assignment

    a. AID assignment to position
    b. Storage and transfer of goods
    c. Personal business affairs

2. Important points from general provisions

3. Summary of contract and university allowances

4. Campus orientation

    a. Office
    b. Personnel and mailing lists
    c. Equipment inventory

5. Mailing procedures (forwarding to in-field staff)

6. Important reference sources of detailed and additional information

Slide Classification Scheme

Anticipating expansion of the program, the need has become evident for the development of a system for filing and retrieval of research information recorded on film. Dr. Cardenas has, in the course of one year, collected a large number of slides. It is anticipated that through his experiences it will be possible to develop a standard system for the project. It is important that there be coordination among the staff as new regional centers are opened.

The majority of the slides will deal with specific cases of weeds, crops, and herbicides. It is anticipated that these must be filed in such a manner that they are individually accessable. There will be a demand for sets of slides relating to general topics and these may be made up and filed as a complete set.

The main problem involved in developing a classification scheme is the development of an index system. Presently the Agricultural/Biological Vocabulary developed by the National Agriculture Library is being studied. The University of California at Santa Cruz is developing an automated slide classification scheme which may be of particular interest.

We anticipate that this project will participate in a large research and information center in weed control being developed to utilize information from throughout the world. It is necessary to develop an information center that will be compatible with other systems, particularly the Current Research Information System.

Herbicide and Weed Susceptibility Chart

Considerable effort has been devoted to collecting and compiling information indicating the relative susceptibility of over 220 weed species to about 70 of the most commonly used herbicides. When completed the information will be published in chart form categorized to include sections on annual broadleaf weeds, annual grass weeds, perennial broadleaf weeds, perennial grasses, aquatic weeds, and brush species. The charts will provide a readily accessible reference for determining the effectiveness of any given herbicide upon any particular weed species.

International Weed Control Handbook

Weed control recommendations, bulletins, research reports, commercial literature, labels, etc. are being collected from as many domestic and foreign companies, foundations, and governmental agencies as possible. From this information an International Weed Control Handbook will be prepared. The handbook lists herbicide treatments for the principal food and fiber crops of the world. Also included are the suggested rates of application, special application techniques, species of weeds controlled, and known geographic limitations of these various herbicides.

Under each crop, the herbicides are categorized as follows:

1. Products currently used and recommended.

2. Products tested extensively and near recommendation.

3. Experimental materials that show promise but have not been tested extensively.

The International Weed Control Handbook is primarily being written to serve as a reference to the vast numbers of commercial and experimental herbicides available throughout the world.

PUBLICATIONS

The following publications in mimeograph form have been made available and can be obtained upon request:

(a) 67-1 Helpful United States-Metric Conversions
(b) 67-2 Weeds of Colombia
(c) 67-3 Weeds of Mexico
(d) 67-4 Weeds of Central America
(e) 67-5 Weeds of Trinidad
(f) 67-6 Weeds of Dominican Republic
(g) 67-7 Weeds of Peru
(h) 67-8 Weeds of Venezuela
(i) 67-9 Weeds of Uruguay
(j) 67-10 Weeds of Puerto Rico

(k) 67-11 Weeds of Chile
(l) 67-12 Weeds of Argentina
(m) 67-13 Weeds of Brasil
(n) 67-14 First Annual Progress Report
(o) 67-15 First Monthly Progress Report - Colombia, August 1967
(p) 68-1 Weed Research Methods for Establishing New Programs*
(q) Administration and Procedures Manual for OSU/AID Project csd-1442
(r) Colombia: A brief description of agriculture and related areas. March 1968. W. A. Furtick, Research Assistant in Geography.

* 68-1 Available on manuscript basis only - currently being prepared for publication.

SUPPORTING AGENCIES AND ORGANIZATIONS

1. Cooperating Industries

Most of the agricultural divisions of U.S. chemical companies

2. Oregon State University Departments

(a) Agricultural Chemistry
(b) Agricultural Economics
(c) Agricultural Engineering
(d) Forestry
(e) Geography
(f) Horticulture
(g) Modern Languages

These departments all contributed substantially to this project. A special project was conducted by the Geography Department. The results of this project are available as a supplement to this annual report upon request.

3. University of Hawaii

The University of Hawaii was a major collaborator in the evaluation of new products under tropical conditions.

4. University of Nebraska

The program in Colombia was in close collaboration with the Nebraska Mission. Their administrative support was invaluable. Dr. Larry Jeffery of the Nebraska staff was a close collaborator on much of the research.

5. ARS, USDA, Aquatic Weed Center, Fort Lauderdale, Florida

Valuable advice and assistance was provided by Dr. Lyle Weldon and Dr. Robert Blackburn of this center.

ADVISORY COMMITTEE

This committee has been helpful in reviewing the progress of this project and offering advice and guidance. We are most grateful to these people:

Dr. Keith Barrons - Director of Biological Research, The Dow Chemical Company, Midland, Michigan

Dr. Will Carpenter - Manager, Herbicide and Fungicide Development, Monsanto Company, St. Louis, Missouri

Dr. W. B. Ennis - Chief, Plant Protection Branch, ARS, USDA, Beltsville, Maryland

Dr. A. H. Lange - Extension Weed Specialist, University of California, Riverside, California

Dr. J. R. Orsenigo - Weed Research Specialist, University of Florida, Belle Glade, Florida