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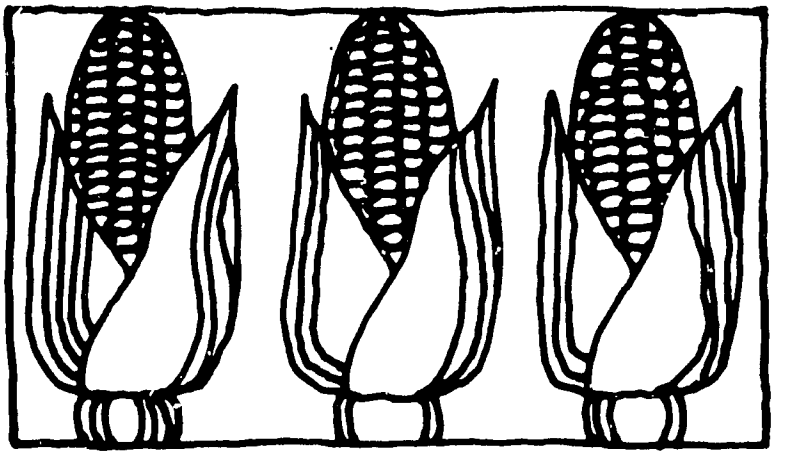
Concluding Report

Weed Control Systems for Representative Farms in Developing Countries



Oregon State University and the U.S. Agency for International Development

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WEED CONTROL SYSTEMS FOR REPRESENTATIVE FARMS IN DEVELOPING COUNTRIES

A contract for research
between the U.S. Agency for International Development and
Oregon State University

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I. PROJECT PROFILE

Project title:	Weed Control Systems for Representative Farms in Developing Countries
Contract no.:	AID/ta-C-1295
Principal investigator:	Dr. Stanley F. Miller, Director International Plant Protection Center Oregon State University, Corvallis OR 97331 / USA
Contract period:	April 1, 1976 to May 31, 1983
Accumulated expenditures for the contract period:	$1,712,566
Cooperating with:	NCPC (National Crop Protection Center), Los Banos, Philippines; CATIE (Centro Agronomico Tropical de Investigacion y Ensenanza), Turrialba, Costa Rica.

II. EXECUTIVE SUMMARY

The unique AID-Oregon State University weed research contract operated from April 1, 1976 through May 31, 1983, conducted resident research programs in Brazil, El Salvador, Thailand, Costa Rica, and the Philippines, plus Corvallis. An estimated 9,680 person-days of OSU professional academic staff time were dedicated to the project in meeting its objectives. Total project expenditures were $1,712,566 with an additional $78,715 provided through cost sharing.

Working with CATIE in Costa Rica, project personnel developed and refined a vegetation management system with nine clear benefits for small farmers, and potential to be fully to partially adopted by at least two out of every three North Atlantic Zone small farmers, generating a minimum estimated $500,000 annual savings and a 122% internal rate of return. The same project-developed weed control technology, tested in Nicaragua by the German international technical assistance group (GTZ), producted a 27% maize yield increase.

Project personnel developed a low cost, easily made spray shield allowing farmers to perform weed control earlier in the cropping cycle and reduce yield losses an estimated 19%. Project input helped modify existing local banking policies, and improved loan conditions for small growers practicing no-till. Project techniques applied to tropical forestry programs advanced tree growth 24% over traditional systems.

An integrated weed control system (handweeding plus herbicide) designed by the project for small upland rice farmers in the Philippines revealed a $42 to $143/ha increased net return to the farmer depending on tenure class and capilal availability. However, extremely poor, highly risk-averse farmers were much less likely to adopt the new technology, according to project research results.

Filipino small farmers growing maize benefitted from introduced new weed control technology, not in directly increased yield, but by having an alternative system to utilize in periods of labor scarcity or for larger holdings. A particular technology was developed, as well, for the noxious weed *Rottboellia exaltata*.

Results of a year-long study of a rapidly spreading troublesome weed in Thailand helped reorient an estimated $20 million investment by the Thai government to more beneficial use, emphasized the need for control measures in irrigation-related systems, and provided a benefit/cost ratio exceeding 35/1. The study's significance drew international acclaim.

Information developed by the AID-OSU project in 1976, based on earlier project research, was utilized by a 1981 World Bank study in Northeast Brazil, thereby not recommending technology with the potential to displace an estimated 144,000 person-days of labor annually.

Research conducted at Corvallis focused on developing appropriate control methods for two of the world's worst weeds. Also, simple, hand held equipment was developed and tested for applicability to small farm use in LDCs. The study of creative use of various mulches was begun.

At Corvallis, the project assembled one of the world's most extensive collections of lever-operated knapsack sprayers; project personnel identified desirable characteristics and gained technical background creating an information resource for missions and others.

The project published a series of useful titles and broadly distributed copies to missions, IARCs, institutes, and LDC recipients on a timely basis, and responded to technical information requests similarly.

Project personnel took part in mission-requested assistance in Pakistan (short course and survey), the Caribbean (workshops and small farm project evaluation), Belize (weed problem evaluation), Tanzania (weed problem assessment), Peru (project paper development), and Argentina (FAO-sponsored short course). Additionally, on-site assistance was provided to Guatemala, Panama, Honduras, El Salvador, and Nicaragua.

In total, project personnel either organized and conducted, or participated in, 49 training short courses or workshops involving 1,396 participants and generating 10,226 person-days of training.

III. THE PROJECT IN FOCUS

A. Weeds and LDC Agriculture

The advancement of agricultural technology has had mixed blessings. For small and medium-sized farming enterprises in many developing countries, increased emphasis on required inputs (fertilizer, improved seed, and irrigation) and their associated costs placed dramatic production increases out of reach. Only the more affluent operators could absorb the cost, not to mention the often increased risk.

Advanced technology also contributed to intensification of weed problems. Some of the new, high-yielding cultivars did not complete as vigorously with weeds as did many native varieties. Additional soil fertility, higher moisture levels, and improved seedbeds for both new and old varieties provided better growing conditions for weeds as well as the crops. Tragically, this combination often resulted in a failure to realize potential gains from costly development projects.

Weed flora shifts occurred as weed control technologies changed, often resulting in a shift from relatively controllable broadleaf varieties to more pernicious grassy species which, once established, became more difficult to control.

B. Critical Questions

The international development community grew increasingly concerned over the need for weed control in developing countries and needed answers to critical questions:

- to what extent do weeds limit production, either by direct competition with crop plants for available nutrients, light, and water, or by limiting area a small farmer can plant to that which he can weed?
- what levels of agricultural technology could, or should, be introduced for weed control given prevailing economic, social, and political restraints?
- to what extent will increasing scarcity of labor and capital change traditional weed control methods?

- what is the interrelationship of weed control technology with other inputs and what priorities emerge as a result?
- how do various weed control systems--including the absence of any control--economically and socially affect the small farmer, his family, the associated labor pool, and the community?

C. Origin of the Project

These concerns resulted in the AID-Oregon State University weed control project (a contractual relationship originated in 1966) being encouraged to study the emerging implications of weed control technology. The formerly production-oriented AID-OSU research effort was restructured in 1973 to include a broader overview of peasant farm problems and to work toward designing weed control systems for representative farms in developing countries.

Concurrently, the project assumed the added dimension of attempting to assess the social and economic impact of weed control technology related to employment and income distribution. The restructured project undertook programs centered in Brazil (Northeast) and El Salvador. These efforts were carried out in accordance with work plans and terminated in 1976. New project areas were identified in Central America and Southeast Asia and a series of multi-faceted programs launched in these two regions.

D. Aquatic Component

Project staff had become increasingly aware that aquatic weeds are a serious problem throughout the tropics and subtropics of the world, especially in developing countries. Since 1960, explosive growth of aquatic weeds in major hydrological systems of several developing countries had reduced or restricted water availability. Where water systems serve multiple purposes, e.g., irrigation, transportation, cooking, sewage disposal, and hygiene, in Southeast Asia, for example, loss of ready access to water would cause serious sociological problems.

In agriculture, aquatic plants occupy space needed for water storage. Moreover, through transpiration, they accelerate the loss of water from a free water system 3 to 8 times over that of a clear surface. This threat becomes specially pertinent for critically water-short regions.

To address aquatic weed problems, the AID-OSU weed program arranged for the University of Florida to conduct an aquatic weed activity under a subcontract. An agreement was signed and work begun in April 1976. Under the agreement, the U. of F. aquatic weed experts provided technical assistance through short-term consultations with governments of developing countries as well as provide a reference and information center to the same group of nations. While most of their activities were financed under the technical assistance contract between AID and OSU, research problems of selected aquatic weeds also were addressed.

IV. PROJECT OBJECTIVES

A. Project Role

The AID-OSU weed control program constitutes but one of many elements in the overall effort to raise food crop production levels in the world's less developed nations. It specifically aims to help institutions in developing countries design, organize, strengthen, and implement weed control programs to reduce food losses due to weed competition and thereby increase rural and urban standards of living.

The program endeavors to work in close collaboration with local, regional, national, and international entities based on sensitivity to stated needs and integration of activities. The goal involves collaboration with nonproject colleagues and counterparts to ultimately increase effectiveness of weed science and control.

Attempts to develop and assess weed control technologies for representative farms in developing countries imply a special emphasis on smaller-sized, subsistence farms. Resulting technologies, or systems, are evaluated in terms of various societal goals and performance criteria, including economic efficiency, and income distribution.

B. Objectives

Specific objectives include:

1. Evaluate and adapt weed control technologies that are agronomically, economically, socially, and environmentally compatible with the endowments of small farms in developing countries.
2. Improve, design, and test appropriate weed control equipment necessary to advance both weed control research and weed control adoption.
3. Study the magnitude of the socio-economic change required to introduce weed control technologies into regions with different inputs, governmental policies, and institutions.

4. Evaluate the impact of alternative weed control technologies on the agricultural sector, taking into account the well-being of the small traditional farm families and the landless agricultural labor pool.
5. Develop procedures for evaluating cost/benefit relationships for aquatic weeds.

V. ACTIVITIES REVIEW

The project conducted programs in numerous geographical areas including Central America, Philippines, Thailand, Brazil, and Corvallis. The Central American work continued the program's long-standing presence in, and association with, Latin America. Activities, findings, and conclusions that follow are presented by geographical region and related to the broad program objectives, as follows:

A. Central America
B. Philippines
C. Thailand
D. Brazil
E. Florida (aquatic program)
F. Corvallis
G. Training

An appendix containing a variety of tables follows the Activities review.

A. CENTRAL AMERICA

1. Association with CATIE

The project collaborated with CATIE (Centro Agronomico Tropical de Investigacion y Ensenanza) at Turrialba, Costa Rica, to provide a weed research component for the center's farming systems group. Two project agronomists took up residence in August 1976. An agricultural economist was later added to the team.

CATIE is a scientific and educational nonprofit autonomous institution established in 1973 as a regional center supporting agricultural development in Central America and the Caribbean.

The AID-OSU weed research effort terminated a resident presence in June 1982, but continued to provide periodic short-term consultation through May 1983.

2. Vegetation Management Systems

Vegetation management systems were developed for farmers operating under widely varying socio-economic conditions, ranging from totally manual farming to more capital intensive systems.

*Project benefit:
Experimental results revealed that improved vegetation management systems could produce major savings for Costa Rican small farmers.

Results from three years and 70 weed management experiments led to the conclusion that no-tillage mulch vegetation management systems, emphasizing pre-planting weed control, offered several important advantages over systems involving mechanical preparation:

1.) avoids dependence on machines;
2.) less sensitive to inclement weather;
3.) greater flexibility in choice of resource mix in the production (weed management) process; i.e., from completely manual to different combinations of manual and capital, to capital intensive systems;

4.) shorter turnaround time between harvest and planting of the following crop;

5.) reduced soil erosion;

6.) reduced late season labor requirements;

7.) can be used on land that is inaccessible to machinery;

8.) generally lower costs;

9.) quite independent of cropping systems, with perhaps the exception of root crops on heavy soils.

a. Yields

Maize yields with no-tillage techniques were equal to, or greater than, those obtained in mechanically prepared fields infested with both annual and perennial weeds (see table 1 for examples).

Consistently superior yields with no-tillage mulch systems during periods of limited rainfall were attributed to the increased soil moisture content resulting from this technique; the vegetative cover on the soil surface (mulch) increases water infiltration and reduces evaporation losses. Not only was there more soil moisture under mulch, but the moisture was retained with less tenacity by the soil colloids, and thus was more readily available to plants.

Table 1. A Comparison of 7 Weed Control Systems for Maize (Cariari, Costa Rica

system	yield shelled maize 13% moisture 1977	1978	labor	weed control cost	cost versus conventional
	---- (kg/ha) ---		(man-days/ha)	($/ha)	(%)
1. Plow + hand weeding	2277	4280	9.0	86	107
2. Plow + atrazine Pre (2.0 kg/ha)	2414	--	2.5	81	101
3. Plow + paraquat Post (.5 kg/ha)	2626	4431	3.5	80	100
4. Mulch + hand weeding	2613	4302	21.0	70	88
5. Glyphosate PP (1.3 kg/ha)	3177	4769	5.5	72	90
6. Paraquat PP (0.75 kg/ha)	2487	4381	5.5	38	48
7. MSMA PP (5.0 kg/ha)	1831	4117	5.5	41	53
8. Paraquat PP + Post (0.75 + 0.5 kg/ha)	--	4653	9.0	62	

PP = preplant
Pre = preemergence
Post = postemergence
Mulch = weeds were cut at ground level the day of planting

b. Other Factors

The majority of experiments involving various vegetation management systems and fertility levels (phosphorus and nitrogen) indicate that maize yields at any given fertility level were higher for no-tillage than for systems involving tillage. Apparently greater moisture under the mulch strongly influenced fertilizer efficiency (table 2).

Table 2. Phosphorus, Moisture, and Maize Yields (Turrialba, Costa Rica).

tillage systems	phosphorus	yield		soil moisture	
		maize	beans	30 DAP	60 DAP
	(kg/ha)	---(kg/ha)---		------(%)------	
Plowed	0	1645	902	35.8	38
	100	2727	801		
	200	2293	1076		
	300	2676	973		
	400	2944	883		
No-till	0	4143	386	39.7	41
	100	4368	306		
	200	4366	380		
	300	5194	506		
	400	5451	384		

Soil Type: Typic Dystropept. Clay loam.

Comparisons of interactions between vegetation management systems and insects revealed that crop-attacking insects reduced maize yields less in no-tillage plots than in plowed plots, particularly in the absence of any insecticide application. The incidence of two insects, Diabrotica balteata and Spodoptera frugiperda, was less for no-tilled treatments than for methods involving plowing.

No-tillage systems out-performed those based on tillage in terms of economic efficiency.

c. Vegetation Management Systems and Other Crops

Bean yields were equal in plowed and no-tillage treatments for monocrop beans and beans intercropped with cassava. When intercropped with maize, bean yields were generally inferior in the no-tillage treatments. However, this was thought to be caused by the greater maize growth in these treatments.

Slug damage to common beans and lima beans was greater in no-tillage plots than the tilled plots, although yields were not significantly reduced in several cases.

Cassava yields were significantly less with the no-tillage technique in a clay loam soil, but not in sandy loam soils.

3. Technology Adoption

*Project benefit:
The weed control technology developed by the project was fully adopted by one out of every four small farmers exposed to it. The internal rate of return for the project investment is estimated to be 122%.

a. Farmers evaluate vegetation management

Adoption of the chemical mulch weed control procedure developed and tested by the AID/OSU-CATIE program in Costa Rica was monitored. Seventeen farmers were selected in two areas--Guacimo and Cariari--taught the technology, and provided inputs for the demonstration trials during the first semester of 1981.

Three treatments were tested: 1.) the farmer's weed control practices; 2.) the proposed no-tillage weed control technology; and, 3.) the proposed weed control technology plus the CATIE proposed fertilizer and insect control program.

The proposed technology included preplant vegetation control using herbicides and the introduction of a project-developed spray shield required for herbicide application.

Farm records were maintained on a weekly basis for all farm and household activities and consumption.

During the second semester (dry season), 10 additional farms were added. The proposed weed control technology was also slightly modified in recognition of the very high cost of the herbicide glyphosate which was used on perennial weeds. The agronomic and economic results are shown in tables 3, 4, and 5.

Table 3. Agronomic Results of the Validation of Three Weed Control Systems 1981, Maize-maize

alternatives	ave. yield (kg/ha)	economics cash costs ($/ha)	labor (hrs/ha)
First semester, 1981			
1. Improved practice	3075	70	197
2. Improved practice plus insecticide and fertilizer	3272	102	235
3. Farmers' practice	2617	50	198
Second semester, 1981			
1. Improved practice	2486	79	244
2. Improved practice plus insecticide	2248	64	273
3. Farmers' practice	2032	37	255

Analyzing the combined results of the two semesters, it was concluded: (a) The proposed weed control technology is agronomically and economically viable in comparison to the traditional technology on farms where annual weeds are the predominant species. The proposed technology

yields more per hectare, provides higher returns to the factors of production, improves the efficiency of factor usage, increases net farm income, and is easily implemented; and (b) Where perennial weeds dominate, the glyphosate treatments resulted in higher agronomic yields, but due to the high price of glyphosate, the economic results are not competitive with the farmer's practice. When glyphosate is replaced by paraquat, the agronomic advantage is lost.

Table 4. Selected Economic Comparison of Two Alternative Weed Control Systems (for 1 hectare) First Semester, 1981

system	annuals			perennials		
	NI	RCI	RC	NI	RCI	RC
1. Improved weed control	307	13	2	175	5	1
2. Farmers' practice	236	12	2	209	11	1

NI = net cash/ha - values of production - (cash cost + value of labor)/ha.
RCI = rate of return to cash cost.
RC = return to labor.

Table 5. Selected Economic Comparison of Two Alternative Weed Control Systems (estimated for 1 ha at 33,000 plants/ha), Second Semester 1981

alternatives	annual weeds			perennial weeds		
	NI	RCI	RC	NI	RCI	RC
1. Improved weed control	244	24	2	146	21	1
2. Farmers' Practice	195	38	1	165	25	1

NI = net cash/ha - values of production - (cash cost + value of labor)/ha.
RCI = rate of return to cash cost.
RC = return to labor.

b. Benefits

Potential benefits from the improved weed control system are high. If it is assumed that the income advantage for the improved weed control technology will be maintained in the future and that 63% of the maize acreage in the North Atlantic Zone (11,000 has) are infested with annual weeds (the percentage was documented in a farm survey), net regional farm income will increase by approximately $500,000/year. The internal rate of return for the entire project cost in Central America ($410,902) will be 121.7%.

Of course, the technology is applicable outside the North Atlantic Zone of Costa Rica. If part of the development costs were assigned to other production areas where the technology is applicable, the internal rate of return would be much higher.

c. Adoption Forecasting Method Developed

*Project benefit:
A technique developed by the project forecasts which group of small farmers will benefit most from improved vegetation management; it thus can facilitate adoption and realization of benefits.

Following the 1981 season, farmers were monitored to assess their continued acceptance of the technologies during the first semester of 1982 with the purpose of selecting group characteristics which might be useful in predicting adoption. The monitoring activities permitted determining different levels of adoption among the maize growers. Four categories were identified: (a) Nonadopters (group 1); (b) low adopters, those farmers who used the preplant controls (group 2); (c) medium adopters, those who used the application shield (group 3); and (d) adopters of all practices and doses of chemical in the weed control technology.

Out of 32 farmers, some who had previous experience with the project and some who did not, 26% were full adopters, 37% were medium adopters, 26% were low adopters, and 11% did not adopt any of the practices.

Discriminate analysis was used to estimate the classification coefficients for the productive equation and to establish a profile of like various adopter classes. Twelve variables were hypothesized to be key factors in adoption and a predictive equation was estimated.

This procedure provides a forecasting tool that allows the classification of a given farmer into one of the adoption groups. Ex-post, the classification was nearly perfect (see table 6), but its major advantage lies in its ex-ante prediction for extension purposes. It provides a preevaluation of the success of the improvement effort by identifying groups to be targeted. Thus, it aids in planning and budgeting of the effort.

Table 6. Farms Classification by Adoption Groups According to the Discriminate Function, and the Classification Procedures.

No. of farm	original group classif.	functional group classific.
1	4	4
2	2	2
4	3	3
6	3	3
7	3	3
8	1	1
9	3	3
10	2	2
11	2	2
12	4	4
13	3	3
14	2	3*
15	4	4
16	2	2
17	3	3
18	2	2
19	2	2
21	3	3
23	1	1
24	1	1
25	4	4
26	4	4
27	4	4
29	3	3
30	3	3
31	3	3
32	4	1*

* Reclassified farmers

4. Broader Applicability of Technology

*Project benefit:
The project-developed vegetation management technology will produce benefits for small farmers in other areas.

As the work proceeded in Costa Rica, questions were raised as to the potential usefulness of the technology in countries with different ecological and economic environments. A decision was made to test the technology in a similar ecological zone, but dissimilar economic environment, in Nicaragua.

A survey was taken of 42 farms in the Rigoberto Cabezas Project (PRICA) of Nicaragua, located in the Atlantic Plain. The PRICA production pattern was found to be generally similar to that of the NAZ (North Atlantic Zone) of Costa Rica, although cultural practices were started one month earlier. PRICA farmers, however, do not use a mulch, and fields are burned before planting. Also, while NAZ farmers have experimented with herbicides, no interviewed PRICA farmer had used them.

To analyze the PRICA data, a linear programming model was constructed and information generated based on farm size and other constraints. Results predicted a significant income increase with introduction of recommended weed control technology (22%), and a high degree of adoption. Labor demand was not significantly reduced since more land was brought into production.

5. Simple Device Aids Small Farmers

*Project benefit:
The project developed a low-cost, easily made spray shield that allows farmers to perform more timely weed control.

The project developed as part of the mulch system an inexpensive, simple, village fabricated spray shield--and unique method for its use--that enables small farmers safely and effectively to spray

nonselective postemergence herbicides 20 to 25 days after planting rather than waiting until 30 to 40 days when weed-caused yield losses have increased.

The shield (figure 1), attached to the lance of a knapsack sprayer and used in a side-to side motion, contains and directs herbicide droplets that might otherwise hit and damage the crop.

The benefits to the small farmer include:

i. The shield is relatively light, readily fabricated locally, and inexpensive;

ii. It can be used to more effectively and safely apply commonly available herbicides;

iii. Selective, limited chemical weed control aids the small farmer in achieving better control of weeds with less reliance on hired labor;

iv. Improved weed control results in greater crop yields (19%) and less restraint on the extent of land farmed in any one season.

Naturally, to use the shield, the farmer must either own, or have access to, a knapsack sprayer, a major capital item; and, the system involves use of herbicides which could be hazardous if misused. Herbicide cost and availability also must be considered.

Depending on a variety of factors, the average cost for materials and manufacture of the shield ran from $1.70 to $3.95. An imported, ready-made shield costs a minimum of $16.

Details of how to construct and use the spray shield were issued by the project in printed form.

Materials required

- metal sheet, approx. 46 x 50 cm (18 x 20 in.) (aluminium template discarded by printing presses provides cheap lightweight source of sheet);
- scrap metal, approx. 25 x 3 cm (10 x 1 in.);
- 2 screws and wingnuts with washers;
- nozzle body (from existing sprayer), with flat-fan nozzle, 2 washers.

6. Weed Management Recommendations in Central America

Weed control alternatives which are agronomically and economically viable for farmers of specific socio-economic conditions were also developed collaboratively with CATIE staff in the other Central American countries. The information now forms part of the recommended technology package which the CATIE/ROCAP Small Farms Production Systems project has generated for maize, beans, cassava, and rice.

7. Project Impact on Bank Credit Policy

*Project benefit:
Project-supplied information precipitated improved credit policies for Costa Rican small farmers practicing nonmechanized farming.

a. Bank Policy Favored Mechanization

Short term credit (4-6 months) for maize production was available to small farmers in the North Atlantic zone of Costa Rica during the 5 years that the AID-OSU project was active in the area. However, the banks followed a discriminatory policy, giving a maximum loan of $240/ha for no-tillage systems and $375/ha for mechanized systems, both at 8% annual interest.

On January 6, 1981, project staff called a meeting in Guapiles with personnel from MAG (Ministry of Agriculture, including the assistant director of research and several extension agents), ITCO (the land colonization institute), bank loan officers, chemical industry, the University of Costa Rica, and CATIE. Along with CATIE entomologist, J.L. Saunders, project staff presented extensive data showing that insect damage to maize was much less in no-till systems compared with mechanized systems. If there was to be continued promotion of mechanization, the project emphasized that there would also have to be promotion of soil applied insecticides at planting.

b. Policy Altered

The group discussed the fact that the official loan policy was promoting a more expensive technology (tractor rental) that leads to increased dependence on pesticides (insecticides). It was agreed that, as a minimum step, MAG, ITCO and the university should stop promoting mechanization and the banks should give equal loans for the two production systems.

In late 1981, the government announced its new loan policies including equal loans for no-till and mechanized systems.

8. Vegetation Management and the GTZ

*Project benefit:
The project's recommended vegetation management system was utilized by the GTZ in Southwestern Nicaragua producing a 27% maize yield increase.

In 1980, CATIE implemented a farming systems project with GTZ (the West German international aid organization). GTZ personnel formally requested help from the AID-OSU project to elaborate a questionnaire on weeds and later to design no-tillage weed control systems for the GTZ research program in Nicaragua.

GTZ used the project's recommended technology on 75 farms in the southwestern part of Jinotega county, Nicaragua, in a "Testing of Innovations" phase. The area has some 11,000 farms, 87% of which have less than 35 ha.

After one year (two planting cycles on most farms), it was concluded that the recommended zero-tillage technique resulted in a 27% increase in maize yields (1899 vs. 1487 kg/ha) over the traditional system which used one to three plowings with oxen. Furthermore, GTZ also reported a significant yield increase for nitrogen applications with the no-till system.

9. Weed Control in Forestry

*Project benefit:
The project demonstrated that weed control technology can increase tree diameter by 24% in 1.5 years.

The AID-OSU project was requested by CATIE to determine whether some of the vegetation management systems devised for annual crops would have application in the establishment of pine plantations.

Normal practice involves cutting all vegetation at ground level in a 1 meter diameter circle, planting the pine seedling in the center, and hand-weeding every 4 to 6 months. Not only is this a time consuming practice, it fails to protect the seedling trees from severe competition.

In a nonreplicated demonstration conducted by the project, a comparison was made between chemical weed control and hand cutting in 7-year old pine trees. After 18 months, trees growing in an area treated with the herbicide glyphosate had an average increase in diameter 24% greater than trees growing in an area where the weeds had been cut by hand a total of six times.

In 1981, the ROCAP/CATIE Firewood project compared six methods of site preparation/vegetation management for the establishment of young trees in Leon, Nicaragua. After 14 months, the chemically prepared mulch technique resulted in a higher percent of establishment of trees and an average advantage of over 50% in diameter and 40% in height of trees compared with the traditional method (clearing to bare ground at planting with 5 handweedings in the 14 months).

10. Socio-economic Research in El Salvador

Socio-economic research conducted earlier on the relationship and impact of various weed control systems on small, basic grain farmers in El Salvador was formalized in a doctoral dissertation. The study, performed by R.E. Fonollera (presently Dean of Agriculture at Central Mindanao University in the Philippines), was entitled: The Impacts of

Government Market Intervention on Weed Control Technology, Income and Employment - A Case Study of Basic Grain Farmers in El Salvador, Central America.

The major conclusions were: the presence of price distortions and off-farm employment alternatives were insufficient to induce changes in weed control technology on small and medium size farms. The most efficient system, both from an individual and social point of view, was the use of manual weed control. However, large farms appeared to be sensitive to direct and indirect government subsidies with the result that herbicide use was found on 75% to 87% of the total large farm area whenever direct or indirect capital subsidies were in effect.

11. Project Engaged in a Variety of Efforts in Central America

In addition to the specific vegetation management research conducted by the project, the socio-economic investigation, and the on-farm validation of technology, project personnel:

- helped plan and execute 28 experiments with 13 graduate students;
- coordinated nine experiments for four short-term trainees from other Central American nations;
- served as major professor for six thesis research programs; more than half of the experiments were sited in farmers' fields and the remainder on various experiment stations.

In addition to the work carried on in Costa Rica, project personnel:

- travelled to Panama numerous times to help establish weed control research, meet with US AID mission representatives, and consult with Panamanian officials;
- travelled to Honduras to discuss and assist with weed control aspects of Honduras' cropping systems program; and
- conducted weed control seminars in Panama, Nicaragua, Guatemala, and El Salvador.

B. PHILIPPINES

1. Association with NCPC

From 1977 to 1981 the AID-OSU project stationed two agronomists, who were later joined by an agricultural economist, at the National Crop Protection Center of the Philippines (NCPC). The research conducted by this cooperative effort can be divided into three categories: upland rice; maize-Mindanao; and, maize-Batangas.

a. Upland Rice

Weeds seriously affect the yields of upland rice. It is estimated that the average yield reduction in upland rice using traditional weed control is 30%. Controlling weeds is a major cost to upland rice producers with farmers using up to 900 person-hours/ha to hand-weed upland rice. Labor costs in the critical early stages of rice production are increasing due to alternative demands for labor both on and off the farm. Labor costs increased 81% over the 4-year period (1977-81), while rice prices at the farm increased only 40%. Thus, the upland rice producer found himself in a difficult cost-price squeeze.

In the four consecutive wet seasons of 1978-81, trials were conducted in farmers' fields in various locations in the Philippines. The results of one year led to modifying the experiment in subsequent years. The field experiments indicate the progression of the researchers' efforts in developing both agronomically and economically effective weed control alternatives for the Filipino upland rice farmer. Efforts were made to combine new technologies--improved rice varieties, fertilizer, and herbicide practices--with the farmer's traditional weeding practices of cultivation and handweeding.

Based on existing information, project staff selected some promising herbicides to screen for weed control efficacy in an improved variety of upland rice. Results from these trials led to further experimentation with rates of butachlor--a herbicide proven to have the greatest potential of those tested.

Butachlor was tested by itself and in combination with other herbicides and farmers' practices and compared to various check treatments including the farmers' traditional practice. Results showed that butachlor's herbicidal effect dissipates about 40 days after application under upland conditions, and weed growth beginning at this time can still prevent optimum yields. Follow-up control was required for both newly germinating weeds and weeds that escaped the initial herbicide application. Further testing revealed that total reliance on herbicides would cause shifts of the weed flora to species possessing some degree of tolerance to the herbicides.

Further, it was determined that the integrated weed control system of butachlor followed by handweeding resulted in a marked increase in yields over traditional methods; improvement occurred between sites as well as between years (table 7).

Table 7. Weed Control Impact on Yields of Upland Rice, 1981.

treatment	San Rogue	Bagumbayan	San Felipe	Bagong Pook	Inosloban	Sampaloc	$\bar{x}$
	(kg/ha at 14% moisture)						
1. farmers' practice	1295	927	667	2134	1340	530	1060.5
2. 1 kg butachlor + handweeding	1414	1040	603	2264	2051	883	1375.83
3. 1 kg butachlor + 0.5 2,4-D	1392	242	338	1589	937	406	817.33
4. 2 kg butachlor + handweeding	1779	1077	570	2363	2253	1429	1578.50

The integrated weed control system also proved economically superior to the farmers' practice in many situations. Specifically, research revealed:

i). butachlor followed by handweeding provides the highest average net revenues over sites and over years for all farm cases studied, an increase of $143/ha for commercial farmers and $42/ha for tenant farmers using family labor.

ii). in spite of the previous conclusion, the extremely risk-averse farmer who is constrained by lack of credit and seeking to minimize his risk may continue to rely on the traditional practices. Since this is the largest farmer group, adoption may be slow.

iii). sensitivity analyses revealed that input and product prices influence the treatment that maximizes net revenue. The preferred treatment is very sensitive to changes in the labor opportunity cost and not as sensitive to changes in herbicide and product prices.

b. Economic Model Developed

Starting with 5 years of on-farm data collected by staff of the International Rice Research Institute, an AID-OSU project economist designed an economic model to analyze the data, plus additional supplementary material, and address these objectives:

- describe and analyze the role of weed management in existing cropping systems on one area's farmers;
- examine various states of farm size, tenure, and family size, as well as cash and credit constraints, through a decision model;
- identify those elements of newer weed control systems technology with greatest potential for adoption by small farmers;
- examine the effect of introducing newer weed control systems technology on expected farm net revenue and associated risk, impact on farm labor relative to activities, and ultimate influence on types and varieties of crops grown and extent of farm size;
- predict the regional socio-economic implications for farmers, and others, of widespread adoption of newer weed control systems.

c. Maize-Mindanao

The small-scale maize farmer on the southern island of Mindanao grows crops under a staggering array of adverse conditions. Excess rain, droughts, insects, and diseases take a regular toll of already low yields from native varieties commonly used. Weed problems facing these farmers are also particularly severe. Nearly every cultural practice the farmer uses seems to favor the growth of the very aggressive weed, itchgrass, or Rottboellia exaltata.

Yield reductions due to R. exaltata competition can be as high as 70%. Researchers estimate that in the wet and dry seasons, losses due to R. exaltata left in the maize rows after inter-row cultivation averaged 23%. In addition, seeds produced by remaining weeds assure rapid build-up of future weed populations.

Traditional off-barring and hilling-up cultivations are inadequate for controlling weeds in areas where maize is planted year around. Handweeding is performed by some farmers who can afford to hire labor, or whose parcels are small enough to be weeded by family labor. But, with an average farm size of 5.3 ha in some areas of Mindanao, it is unlikely that a large percentage of maize farmers are able to handweed their total holdings.

The recent introduction of a soil-applied preemergence herbicide may offer an alternative weed control practice for both large and small corn farmers with R. exaltata infested fields. Few other chemicals are as successful as pendimethalin for controlling this weed in corn.

Trials were conducted in Mindanao during the period 1977-81; (an example of one experiment is shown in table 8. Analysis of experiments showed:

i.) major yield changes due to weather conditions;

ii.) generally, superior yields of maize during the wet season, often 100% higher;

iii.) net revenues from alternative weed control practices changed with the tenure status and the cost structure of individual farms;

iv.) differences among the net revenues of the various treatments considered were not great; pendimethalin treatment carried a slight economic advantage in certain farm situations;

v.) fertilizer did not effectively substitute for weed control under conditions of adequate moisture and where R. exaltata was a major weed, nor did competition from intercropping maize with mungbean.

Table 8. Net Revenues from Maize Production for Alternative Farm Cases; Mindanao, 1981).

treatment	case 1		case 2		case 3	
	wet	dry	wet	dry	wet	dry
	($/ha)					
1. Farmer's practice (off-bar + hill-up)	404	-32	217	-1	255	-40
2. Intensive farmer's practice (trt.1, + handweeding)	410	-37	216	-20	256	-54
3. 1.25 kg ai/ha pendimethalin broadcast + 1.5 kg ai/ha	372	-63	241	23	218	-76
4. 1.25 kg ai/ha pendimethalin branded + hill-up	453	-27	254	13	286	-39
5. 1.25 kg ai/ha pendimethalin banded	402	-18	223	13	248	-35

Farm Cases:

1: owner operator who uses bank credit and sells his maize to NFA; variable treatment labor valued at 1981 wage rate.

2: tenant operator and land owner who share crop equally; land owner provides all cash inputs.

3: tenant operator who provides all inputs and pays land owner 1/4 of the crop.

Major differences were noted between the response of maize variety to alternative weed control systems. A system of hybrid seed coupled with favorable growing conditions and integrated weed control (1.25 kg ai/ha pendimethalin banded + hill-up) maximizes net returns in the wet season. However, a traditional variety coupled with a traditional weed control system maximized net returns during the dry season. This apparent differing varietal response to combinations of moisture, weed, and fertility levels warrants further investigation and must be resolved if small farmers are to accept new weed control technologies.

d. Maize-Batangas

Small farmers in Batangas province and other upland areas of the Philippines commonly plant maize in the dry season following upland rice. Rice is grown primarily for home consumption while maize is the main cash crop. Maize is especially important because it provides cash for the family, and to repay loans used to purchase inputs for both the rice and maize crops.

Maize crop yield is affected by uncertain weather conditions during the growing season; the crop is planted late in the wet season and is subjected to varying levels of moisture stress. Following the successful use of a no-tillage mulch system for maize production developed by project staff in Costa Rica, it was decided to test a modified version under Philippine conditions. Earlier planting and reduced weed pressure were anticipated. From research results it can be concluded (see table 9) that zero-tillage maize production in Batangas produced yields equal to or even greater than the farmers practice, but the net revenues were either equal to or less than those obtained from the farmers' practice.

Table 9. Net Revenue per Hectare of Maize for Farm Cases 1 and 2 at Sto. Tomas and Tanauan, 1979-80.

treatments	Sto. Tomas farm 1 E(NR)	Sto. Tomas farm 2 E(NR)	Tanauan farm 1 E(NR)	Tanauan farm 2 E(NR)
	($/ha)			
1. Farmer's practice	263	334	289	369
2. Farmer's planting practice + atrazine, pendimethalin and paraquat	198	285	245	348
3. Jab planter + atrazine, pendimethalin and paraquat	239	348	245	358
4. Jab planter + paraquat and paraquat wiped-on	282	364	282	364
5. Jab planter + glyphosate and paraquat wiped-on	164	246	197	291

Net revenue is gross revenue less variable treatment costs.

Farm cases:

1: farmer uses credit to purchase herbicides, has zero opportunity cost on weeding labor and is a tenant operator.

2: farmer uses his own cash, applies the prevailing wage rate to weeding labor, and is an owner operator.

C. THAILAND

1. Severe Weed Problem Identified

At the request of the Thai Deputy Undersecretary of Agriculture, the AID-OSU project undertook a study to assess the economic impact of *Mimosa pigra*, a semi-aquatic herbaceous plant originally introduced into Thailand to reduce soil erosion on steep slopes. It had, however, become a serious pest threatening waterways and agriculture in the entire Mekong River System. The Ford Foundation and Chiang Mai University were also contacted and agreed to provide partial financial and technical support to the study.

Specific objectives of the study were:

i.) determine the circumstances under which the Thai Government or the private sector should undertake control programs of *Mimosa pigra*;

ii.) determine the most economical control method where control is indicated.

2. Research Results Presented

The published results of the study indicated that economic returns to investment in control of *M. pigra* in irrigation systems and reservoirs are very high. By contrast, economic returns for control along roads are negative, but overriding noneconomic factors (particularly safety considerations) make control mandatory.

In agricultural land, normal farming activities effectively control the weed: there would be virtually no benefits to a project directed specifically at *M. pigra* control, only costs, so economic returns to control would be highly negative. In nonagricultural land, economic returns to control would be highly negative: opportunity costs as well as direct control costs would be incurred and no benefits would be forthcoming. The possible exception to the above would be if *M. pigra* is proven to be a significant alternate host for crop destroying insects. In that event, control of the weed in nonagricultural land and along roads could result in positive economic returns.

In rivers, economic returns to control are variable, hinging on the value of reducing the rate of colonization of currently uninfested areas. Economic returns are highly positive along river segments immediately downstream from infested areas. In river segments far from uninfested areas, where colonization would not be a factor, economic returns to control are negative.

3. Impact of Results

*Project benefit:
The study results helped reorient a multi-million dollar *M. pigra* control program away from agricultural land to the irrigation and reservoir water system where the B/C ratio was substantially higher.

As a result of the study, a proposed multi-million dollar project to control *M. pigra* in agricultural land was suspended. The investment was redirected from the agricultural level where the B/C ratio was less than one to investment in control measures within the irrigation systems, rivers, and reservoirs where the B/C ratio exceeded 35 to one.

Thus, for a relatively small investment of $89,995 (table 14), the project was able to reorient an estimated investment of $20 million to the benefit of the Thai Government.

The journal, Australian Weeds, referring to the published study, Economic Returns to Investment in Control of Mimosa Pigra in Thailand, stated, "a significant book... one of the very few cases in which a detailed study of the economic impact of a weed has been made before significant sums have been allocated to research into its control." Also, "the main value of this book outside Southeast Asia is that it shows that the economic implications of a weed can be relatively cheaply and quickly identified and quantified before significant research is undertaken into its control. This allows a much firmer base for allocating priorities in weed research."

D. BRAZIL

1. Assistance with Short Courses

An AID-OSU project weed scientist helped organize and present a 2-day weed control short course as part of the Brazilian Enterprise for Agricultural Research (EMBRAPA) 3-week, First National Cassava Production course in Cruz das Almas, May 1976. The effort included lectures on basic weed research principles, field weed identification, demonstration and calibration of application equipment, and other information.

2. Project Information Utilized

*Project benefit:
Information developed by the AID-OSU project in 1976 was used by a later program to avoid recommending labor-displacing agricultural technology.

Previous work reported by the project (in 1977) could not substantiate increased yields for the dry, inland Agreste zone of Northeast Brazil due to changes in weed control practices. In contrast, the project recommend that the use of herbicides in basic food crops should not be promoted in the Agreste zone. In the township of Caruaru (population 150,000), herbicide-based technology had potential to cause a loss of 144,000 person-days of labor/year, with virtually no alternative employment.

In 1981, a project agricultural economist was invited to spend 3 weeks working with an EMBRAPA/IICA/World Bank project economist in Northeast Brazil. The economist working for the World Bank stated that the data and recommendations generated earlier by the AID-OSU project were used as justification for a technology that did not include herbicides for production of basic food crops in a large $30 million dollar development program in the Agreste area. Potential benefits to the farm laborers in terms of continued employment equally exceed $1 million/yr.

E. UNIVERSITY OF FLORIDA

Through the contract between Oregon State University and the University of Florida (Gainesville) to carry out an aquatic weed component of the overall AID weed control systems effort falls under the AID-OSU weed control technical assistance contract, several U. of F. activities closely relate to the research effort as well.

1. Thai Request and Response

The National Research Council (NRC) of Thailand requested (through USAID channels) that the AID-OSU aquatic project supply assistance for developing an aquatic weed control program and training course. The proposed program's scope and size were considered excessive without being preceded by a thorough assessment of the water weed problem in Thailand.

In responding to the request, the project recommended an alternative program including a 3-week short course and a 2-week field assessment of aquatic weeds in Thailand. The NRC withdrew its initial request and submitted a second incorporating these recommendations. Supplemental funds were requested from, and approved by, AID central programs to conduct the training course and assessment trip.

The training course was organized by the Coordinating Subcommittee on Aquatic Weeds (CSAW) of NRC and conducted at the Royal Irrigation Department during April 1977. Twenty-five representatives of Thai governmental agencies and universities attended the course with instruction provided by a joint U.S.-Thai 11-person team.

The course consisted of lectures during the morning and laboratories or demonstrations during the afternoons. Two 1-day field trips were conducted to observe aquatic weed problems in various aquatic systems.

The training course emphasized the "systems ecology" approach and the critical nature of understanding aquatic systems as a whole before considering control measures. Participants were told that aquatic weed problems are the result of serious alterations in the aquatic ecosystem, and that control programs designed for a particular water system should contain steps to correct the alterations causing the problem.

Lectures also stressed that the control measures cited were currently being developed or practiced in the U.S. and that these techniques provide a foundation upon which a modified program could be devised for use in Thailand.

2. Assessment Study

A 5-person joint Thai-U.S. team conducted a 2-week assessment trip to provide on-site evaluation of the major aquatic weed problems throughout Thailand. The group aimed to: determine the extent of aquatic weed problems; identify procedures for assessing their economic impact; and formulate a plan of action for control programs.

A report covering the Thai project activities was prepared and 47 copies disseminated. It was during this study that the problem of *Mimosa pigra* was raised (leading to the study mentioned in this report under "Thailand").

3. Biocontrol Agents Sought

To complement the study of *Mimosa pigra* control economics being conducted in Thailand, University of Flordia scientists mounted surveys for biological control agents. Search and survey activities were conducted in the Corpus Christi area of Texas, and in Honduras. A number of insects were found feeding on *M. pigra* in Honduras.

Additionally, close contact was established with other *M. pigra* research teams in Australia, Brazil, Paraguay, and Bolivia, all areas where the weed is a major pest.

F. CORVALLIS

1. Mulch Systems Investigated

*Project benefit:
The AID-OSU project supported publication of a workshop concerning mulch techniques and distributed 366 copies to recipients in LDCs.

The concept of using one vegetation biomass to help control another is not, in itself, new. Farmers have long utilized mulching concepts. As already mentioned, mulching using a "dead mulch" (hand-cut or chemically killed weed growth) was found to have weed control potential as a part of the nontillage approach developed in Costa Rica.

A second mulching approach, that of using live, or growing plants to suppress unwanted plants, formed the basis for research begun at Corvallis. Legumes planted at selected times were anticipated to out-compete weeds, help maintain (or improve) soil fertility, prevent soil erosion, but not negatively affect the desired crop plants.

Trials were begun in 1982 in Oregon's Willamette Valley. One set of experiments was based on investigating over 40 legumes, grasses, and combinations for their long-term effects. Time of planting (spring or fall) was included as a variable. In another, related research series, New Zealand white clover, planted at different times, was utilized as a cover under maize to suppress weeds, improve moisture management, and contribute soil nutrients as well as possibly a crop value (feed).

Project members played a prominent role in helping organize a 1982 workshop, "Crop Production Using Cover Crops and Sods as Living Mulches," and the International Plant Protection Center, using project funds in part, published the workshop proceedings and distributed (to date) over 350 copies to LDCs.

2. Equipment Development and Assessment

In addition to the development of the spray shield in Costa Rica, several items of equipment appropriate for small-scale farmers were investigated by project personnel at Corvallis.

a. Controlled Droplet Applicator

The concept of a hand-held spinning disc pesticide applicator matured into reality with several firms marketing units in the 1970s. The best known model from Micron in the U.K. (Herbi), was marketed in many countries as a relatively low-cost device that also significantly reduces the amount of water required for application in comparison to conventional spraying. Since availability of water or the labor to carry it are often limiting factors in herbicide use, any reduction from the common 100 to 500 liters/ha is a potential improvement for small farmers.

Power to operate the small electric motor driving the disc comes from flashlight batteries (D cells). Liquid pesticide is carried in a container on one end of a long tube; gravity feeds the liquid to the disc when the tube is angled downward. The unit produces a circular spray pattern.

Tests were conducted at Corvallis (table 10) indicating that for herbicide application, the spinning disc approach worked effectively under very specific conditions, but also presented certain drawbacks and thus did not constitute "an ideal" applicator for use in everyday small-scale farming weed control.

Table 10. Glyphosate Applied to *Agropyron repens* with Herbi and a Conventional Plot Sprayer

treatment	rate	method	control level trial 1	trial 2	trial 3	avg.
	(lb/ac)		(%)			
glyphosate	.5	Herbi	50	40	40	43
glyphosate	.5	conventional	0	0	0	0
glyphosate	1.0	Herbi	70	70	40	60
glyphosate	1.0	conventional	30	40	20	30
glyphosate	2.0	Herbi	85	85	90	87
glyphosate	2.0	conventional	85	90	80	85
check	2.0	conventional	0	0	0	0

b. Direct Contact Applicators

Another concept that blossomed in the late 1970s was that of weed control by directly wiping or rubbing herbicides onto weed plants. The breakthrough occurred when USDA scientists found that the (then recently introduced) nonselective, translocated herbicide, glyphosate, was capable by capillary action of wicking along a rope. Bringing the rope into contact with weeds transferred the glyphosate.

The method avoided spray drift, reduced the amount of herbicide needed (only that rubbed off onto weeds was utilized), and required very simple equipment--some sort of reservoir and wicking device.

Project personnel, using the concept, designed and constructed several prototype, hand-held "wipers." Limited tests were conducted in the field. The research formed the basis for at least two reports that were widely circulated, including to all AID missions.

c. Knapsack Sprayers

*Project benefit:
Through acquisition of an extensive international collection of lever-operated knapsack sprayers, many of which were contributed at no cost to the project, AID-OSU project personnel have become a key information source for AID/W and missions regarding this agricultural tool widely found in LDCs.

Research at Corvallis followed two paths; first, a series of multi-nozzle booms were constructed and tested to make the knapsack sprayer a useful alternative to higher cost, more sophisticated equipment utilized for conducting weed control research. Information developed (table 11) was published and widely disseminated.

Table 11. Evaluation of Multi-nozzle Booms for Knapsack Sprayers.

boom	materials	overall performance	estimated availability of material	estimated relative cost of fabrication
A	1/8" aluminum pipe, with 1/8" anodized aluminum aircraft fittings.	excellent	difficult	very high
B	3/8" copper (refrigeration) tubing and fittings.	very good, but impractical to disassemble	very good	very low
C	3/8" copper tubing with polypropylene flareless fittings.	good	good	low
D	3/8" copper tubing with brass flareless fittings.	poor due to excessive weight	good	high
E	Bamboo with split eyelet nozzle bodies.	good	good	low
F	Commercial; all plastic.	poor: lacks durability and versatility in swath width options	very good	very low
G	Commercial; thin wall aluminum tubing with plastic fittings.	poor: lacks durability and versatility in swath width options	very good	very low

The second thrust involved establishing a corpus of representative knapsack sprayers at Corvallis so that project personnel became familiar with the breed in general and with the most suitable brands and types available on the world market. The work, which had not been finalized at the termination of the research contract, is ongoing under the existing TA contract extension.

Of 36 sprayers collected from 25 firms in 15 countries, 21 units were provided without cost to the project.

d. Specialized Planting Needs

Project scientists in Costa Rica observed that farmers used a pointed stick to plant seed through mulch. If the same "pointed stick" concept could be employed, but improved to also deposit a small amount of fertilizer near the seed, there would be advantages to the farmer in terms of better germination and increased yield.

Several prototype combination jab planters and fertilizer applicators were constructed at Corvallis. One was sent to Costa Rica, and one to the Philippines. Despite the apparent benefits of the concept, the prototypes proved to be unacceptable and the matter was dropped.

3. Novel Method Herbicide Application

*Project benefit:
An innovative weed control method developed by the USDA was tested in Central America by the AID-OSU project and found to be both feasible and promising.

A USDA weed scientist's research based on using small amounts of the thiocarbamate herbicide EPTC to achieve effective in-row field bean weed control led the AID-OSU weed project to invite him to test and evaluate the method under Central American conditions.

During September and October, 1978, the USDA scientist and a project weed scientist established experiments with the new methods at three locations in Costa Rica and one location in El Salvador.

EPTC can be applied (as either granule or liquid) to field beans planted in rows or hills. The beans tolerate the herbicide, while weeds growing in the row or hill--those most damaging to the crop seedlings--are controlled. A further refinement involves coating the bean seeds with herbicide impregnated lime. The herbicide is slowly released from the coating to create a treated area around the seed.

The Central American experiments resulted in complete control of the grassy weed Sorghum vulgare in a 50 to 80 mm wide band straddling the seed row. The EPTC treatment worked effectively on the heavy, medium, and sandy soils used for the tests.

Both methods of EPTC application--granules in the row or herbicide impregnated seed--offer advantages to the small-plot bean farmer:

i.) less herbicide is needed as only a small portion of the land, as little as 10% to 20% of the field, receives treatment;

ii.) reduced amounts of herbicide result in lower input costs;

iii.) use of granules or coated seed avoids potential problems associated with mixing and spraying chemicals;

iv.) in-the-row weed control reduces weed-seedling competition and allows for less costly methods of weed control between the rows (hoeing, or mechanical weed control);

v.) neither method requires any additional equipment as herbicide placement occurs simultaneously with seeding;

vi.) no additional passes across the field are needed to soil-incorporate the volatile EPTC.

The treated seed method is more convenient for the farmer as he works with just seed. However, a factory operation to coat and impregnate the seed would be needed. In contrast, applying granules in the row with untreated seed allows the farmer to use his own seed and commercially available granular herbicides.

The collaborative research conducted in Central America on the two methods during 1978 established feasibility and confirmed the promise of the two methods.

4. Two of the World's Worst Weeds

a. Itchgrass

Rottboellia exaltata (itchgrass) is a rank, agressive, annual grass creating problems in many regions and earning it a place among the world's worst weeds. It has the ability to grow taller than most crops, produce a flush of growth at any time during the crop season, grow equally well in sun or shade, and in the bargain produce stiff, barb-like hairs that are extremely irritating to human skin.

Project personnel encountered the weed in the Philippines and Central America and investigated approaches to controlling it. While it was initially susceptible to certain herbicides, the treatments tended to loose effectiveness as the season lengthened. Growing a mungbean crop between rows of corn helped to suppress R. exaltata during the early part of the season. However, soon after mungbean harvest, R. exaltata rapidly filled empty spaces.

A graduate research project (still underway at Corvallis) involved a weed biology study on R. exaltata. Three biotypes are being crossed and their F_2 progeny are being tested for adaptability to new environments. Differences in susceptibility to herbicides and other stresses are also being investigated.

If the research leads to any more effective way of controlling R. exaltata, the potential benefits to the agricultural segment of several LDCs is incalculable.

b. Nutsedge

Purple nutsedge (Cyperus rotundus L.) is also acknowledged as one of the world's most troublesome weeds. It is nearly impossible to control by either manual methods or herbicides alone. Glyphosate has shown promise of being the most effective material on the market.

A project agronomist first conducted nutsedge control field research in El Salvador and continued investigation efforts at Corvallis during the 1977-78. A series of growth chamber studies he designed were aimed at determining how environmental factors affected the performance of glyphosate. Results indicate that both low humidity and high moisture stress reduced glyphosate's effect on nutsedge; these periods should be avoided in actual weed control practice.

5. Research Literature

In addition to the major publications produced directly by project personnel (see: appendixes), support was given to other scholarly efforts.

The project not only provided an earlier monetary grant to support research, but also assisted with distribution and publicity for a landmark publication. The work, The World's Worst Weeds, Distribution and Biology, by Drs. LeRoy Holm, Donald Plucknett, Juan Pancho, and James Herberger, stands as a unique international reference published through the University of Hawaii Press for the East-West Center's Food Institute. Descriptions of 76 weed species are presented in full detail with emphasis on the 18 most destructive species in order of their impact on world agriculture. Taxonomic data are supplemented by world distribution maps.

On another front, IPPC (with project support) commissioned preparation of a monograph focusing on weed competition, that is, the existence and extent of crop growth reduction attributable to weeds. Professor R.L. Zimdahl of Colorado State University undertook the effort to produce a definitive compilation of world data. The final result was published by the project. To date, over 2,000 copies have been distributed (see appendix for country-by-country accounting).

Work initiated and conducted by a project weed specialist in El Salvador formed the basis for an 18-page, full color pamphlet (in Spanish) dedicated to the problems and control of nutsedge (*Cyperus rotundus* L.).

The publication, published by the Centro Nacional de Tecnologia Agropecuaria (CENTA) in El Salvador, was co-authored by a CENTA weed specialist. The project received 300 copies for distribution worldwide.

6. Handling of Information Requests

The project responded to a large number of requests for technical information and research results. A random check was conducted to establish the nature and number of requests.

All incoming requests were counted and analyzed for one (possibly average) week, March 28 through April 1, 1977. The results were:

i.) - requests received for IPPC/project publications: 43
- total number of copies of publications requested: 222
- requests for information about publications: 10
- requests for information on equipment mentioned in INFOLETTER: 8

- requests for special information: 5
- mailing list address changes, additions, or deletions: 9

ii.) The requests were received from: India, Ethiopia, Singapore, New Zealand, USA, Canada, Belgium, Guatemala, England, Ireland, Philippines, Taiwan/ROC, Jamaica, Switzerland, Nicaragua, Mariana Islands, Colombia, Dominican Republic, Italy, Indonesia, Costa Rica, Mexico, Brazil, Senegal, Uruguay, Thailand, Malaysia, Honduras, El Salvador, Argentina, Panama, and Ecuador.

7. Project Support of Caribbean Effort

At the joint request of USAID/Barbados and the Caribbean Agricultural Research and Development Institute (CARDI), the AID-OSU weed project participated in a review of the CARDI/USAID Caribbean Small Farm Multiple Cropping Program, and in two 1-week weed control workshops.

It was observed that relatively little weed research was being conducted by national institutions in the Caribbean thus making CARDI's weed control efforts highly important.

The workshops, with representation from Trinidad-Tobago, St. Lucia, St. Vincent, Barbados, Grenada, Dominica, St. Kitts-Neves, Antigua, Belize, and Monserrat, included a series of country papers presented by participants. The primary conclusion from these: weeds do constitute a serious constraint to agricultural production in the Caribbean. Also, most of the currently practiced smaller farm weed control involves manual methods, chemical methods are becoming more prevalent.

Also, a project agronomist, responding to a mission request, visited Belize to identify weed problems in citrus and appropriate methods of control. A report, Weed Problems of Citrus in Belize, was published and copies sent to various agencies involved.

8. Project Support of FAO Course

A 4-week, comprehensive weed control short course proposed by the Instituto Nacional de Tecnologia Agropecuaria (INTA), Argentina, and supported by FAO, took place during October-November 1979, at the San Pedro Agricultural experiment station. An AID-OSU weed specialist served as one of the lecturers during the event.

The project also assisted FAO personnel in the initial stages of organizing the course and in contacting individuals outside Argentina for participation as lecturers. IPPC supplied several publications (in Spanish, or bilingual) in sufficient quantity to provide copies to each of the 28 participants.

9. Project Activities in Pakistan

A project weed scientist spent 6 weeks in Pakistan, at the request of USAID/Pakistan, to assist the Pakistani Agricultural Research Council (PARC), in establishing weed control experiments in wheat, and to work with personnel of Experience Incorporated, an AID/Pakistan contractor.

A second objective was to investigate feasibility of a future project site for AID-OSU program in Pakistan.

10. Project Activity in Africa

A 3-week survey and assessment of weed problems in Tanzania was conducted by a team of Tanzanian Ministry of Agriculture agronomist plus an AID-OSU project weed scientist and agricultural economist.

The review, requested by USAID/Dar es Salaam, was designed to assess current weed control practices and to observe and define weed-related problems. The team visited several agricultural research institutes, MoA seed farms, National Agricultural and Food Corporation farms, and private farms in various regions of Tanzania.

Recommendations offered by the team, based on findings, included increased weed science training for Tanzanian officials, establishment of a more formalized nation-wide weed research program, and increased commitment/funding for support of an expanded weed control effort.

Suggestions for specific methods of more effectively controlling several of the most pernicious weed species were presented in the team's report, WEED CONTROL PROBLEMS IN TANZANIA. For implementing and evaluating control strategies, the team emphasized the need to consider the entire socio-economic matrix of the Tanzanian small farm operator.

G. TRAINING

1. Research Training

*Project benefit:
The AID-OSU project provided on-the-job weed research training for 426 individuals in Southeast Asia and Central America.

As part of the research effort in weed control, on-the-job training was provided to 426 agriculturalists and counterparts in Southeast Asia and Central America. Numerous counterparts participated in the project research activities and received many months of direct training. This type of training has proven effective as revealed in a recent post-project review.

a. Training Impact in Ecuador

At the request of Ecuadorian weed research leaders, a review was made of the AID-OSU project's program in Ecuador during 1969-1973. Of the individuals trained in INIAP (Instituto Nacional de Investigaciones Agropecuarias) since 1969, 82% were still working in weed control. One received an M.S. (from Oregon State University) and another is completing an M.S. at Oklahoma State University. The trained INIAP staff have published weed control recommendations for most major commodities in Ecuador and have carried out a training program for their fellow agronomists.

b. Training Courses

*Project benefit:
Project personnel either organized and conducted, or participated in, 49 courses, with 1,396 participants, generating a total of 10,226 person-days of training.

In addition to the on-the-job training, 49 courses in weed control were presented by project personnel in Southeast Asia and Central America during the life of the project. A total of 1,396 persons participated in the courses which ranged from 1 day to 2 months. The record indicates that 10,226 person days of training in mini courses, short courses, and workshops resulted (table 12).

Table 12. Training Courses in Weed Control (April 1, 1976 to May 31, 1983)

date	duration	event	number of participants	held at
5/76	4 days	Weed Control of Cassava	30	Cruz das Almas, Brazil
3/77	2 weeks	Weed Control Short Course	30	Leon, Nicaragua
3/77	1 month	Economic Significance of the Control of Aquatic Weeds and an Assessment of their Economic Significance in Thailand	25	Bankok, Thailand
6/77	2 days	Weed Control in Rice	10	Nueva Ecija, Philippines
8/77	1 day	Weed Control in Rice	30	Los Banos, Philippines
8/77	2 months	Identification, Control and Utilization of Aquatic Plants	10	Gainesville, Florida
10/77	1 day	Pest Management and General Weed Control	15	Central Mindanao, Philippines
10/77	2 days	Research Methods on Weed Control	15	Maligaya, Philippines
10/77	1 day	Weed Control Research Progress	22	Central Mindanao, Philippines
2/78	1 week	Weed Control Short Course	20	Leon, Nicaragua
3/78	1 week	Research Methods in Weed Control	21	Panama

date	duration	event	number of participants	held at
4/78	1 week	First Mindanao Weed Science Workshop	26	Central Mindanao Univ., Philippines
4/78	4 days	Herbicide Application Minicourse	17	Los Banos, Philippines
5/78	4 days	Second Mindanao Weed Science Workshop	20	Xavier Univ. Cagayan de Oro City, Philippines
7/78	3 days	Weed Control for Extentionists	34	San Pedro Sula, Honduras
8/78	1 day	Weed Control in Cacao	30	La Lola, Costa Rica
8/78	4 days	Herbicide Properties and Behavior Minicourse	15	Los Banos, Philippines
9/78	4 days	Third Mindanao Weed Science Workshop	30	Central Mindanao Univ., Philippines
10/78	4 days	Weed Ecology and Identification Minicourse	15	Silang, Philippines
10/78	1 day	Weed Control in Pastures	50	Turrialba, Costa Rica
10/78	2 weeks	Research Methods in Weed Control	20	Managua, Nicaragua
12/78	1 week	Weed Management	36	San Salvador, El Salvador
1/79	1 day	Weed Control in Cacao	11	La Lola, Costa Rica
3/79	4 days	People's School Weed Control Workshop	15	Silang, Philippines
3/79	4 days	Fourth Mindanao Weed Science Workshop	42	BPI, Davao City, Philippines
4/79	1 week	Weed Control in Forests	20	Comayagua, Honduras
5/79	2 days	Equipment Calibration	31	La Lola, Costa Rica

date	duration	event	number of participants	held at
10/79	4 weeks	Weed Control Short Course	28	San Pedro, Argentina
1/80	3 weeks	Weed Management	34	Los Banos, Philippines
4/80	1 week	Weed Management	26	Grenada
4/80	1 week	Weed Management	22	Antiqua
6/80	1 day	Weed Control Developments	20	Guayaquil, Ecuador
6/80	4 days	Intensive Course on Weed Control	14	Honduras
8/80	1 day	Weed Control of Cacao	5	Turrialba, Costa Rica
10/80	1 week	Systems Design Seminar	30	Panama
10/80	1 day	Pastures as a Means of Weed Control	40	Guatamala City, Guatamala
2/81	1 day	Use of Glyphosate to Control *Paspalum fasciculatum*	75	Univ. of Costa Rica, Costa Rica
3/81	3 days	Agronomic Systems for Basic Grains	40	Nicaragua
5/81	2 days	Soybean Weed Control	30	Turrialba, Costa Rica
5/81	1 day	Weed Control in Pastures	37	Turrialba, Costa Rica
8/81	3 days	Weed Control Principles	20	Nicaragua
10/81	6 days	Weed Control Short Courses	22	Nicaragua
12/81	4 days	Integrated Pest Control in Small Farm Production Systems	19	Panama
2/82	4 days	Weed Control for Small Farms	20	Costa Rica
2/82	3 days	Weed Control Short Courses	14	Honduras

date	duration	event	number of participants	held at
4/82	2 days	Weed Control in Cacao	40	Guatemala
11/82	20 days	Weed Control Research	20	Pakistan
2/83	25 days	Weed Control Equipment	150	Indonesia
4/83	3 days	Teaching Weed Science	20	Thailand
5/83	5 days	Integrated Crop Protection Seminar	30	Costa Rica

2. Formal Degree Training

Simultaneously with the informal training in Southeast Asia and Central America, 35 foreign or international oriented students took part in degree training at Oregon State University in weed science or the economics of weed control. Fourteen of these received financial support from the project, or project personnel served as major professor or advisor for the research (table 13).

The research publications of these students are listed in the appendix. Their research has provided insights into many major weed control problems, ranging from the control of particularly noxious tropical weeds like *Cyperus rotundus* and *Rottboellia exaltata* to the economics of specific weed control systems in selected less developed countries. Most of the students have continued in international weed control. R.L. Chase is an example.

During the early years of the project, Chase served as staff specialist in El Salvador where he was instrumental in developing a highly successful program for control of *Cyperus rotundus* His work formed the basis of an 18-page, full color pamphlet (in Spanish) dedicated to the problems and control of nutsedge (*Cyperus rotundus*). The pamphlet was published by the Centro Nacional de Tecnologia Agropecuaria (CENTA) in El Salvador.

Table 13. Formal Training Provided by the AID-OSU Project.

name	country	degree	discipline	present activity
R. Fonollera	Philippines	Ph.D.	AREC	Vice Rector, Central Mindanao University, Philippines
R. Chase	USA	Ph.D.	Weed Science	Weed Control Support Specialist, Somalia
S. Chipenda	Angola	M.Ag.	Weed Science	Weed Specialist, Senegal
T. McCarty	USA	M.Sc.	AREC	Economist, Oregon State Department of Agriculture
A. Cajina	Nicaragua	M.Sc.	AREC	Farm Management Specialist, Nicaragua
J. Sriswasdilek	Thailand	Ph.D.	AREC	Prod. Econ. Kasetsart Univ., Thailand
H. Fisher	USA	Ph.D.	Weed Science	Completing degree, will accept international assignment in 1984
A. Cooper	USA	M.Sc	Weed Science	Completing degree, will accept international assignmentin 1984
B. Abdul-Sulam	Malaysia	M.Ag.	AREC	Malaysian Weed Control Authority
A. Ahmed	Sudan	Ph.D.	AREC	Gezira University, Sudan
S. Bellete	Ethiopia	Ph.D.	AREC	Ministry of Agriculture, Ethopia
G. Robert	USA	Ph.D.	AREC	Chiang Mai University, Thailand
D. O'Brien	Austrailia	Ph.D.	AREC	International Fertilizer Institute, Indonesia
G. Escobar	Colombia	Ph.D.	AREC	CATIE, Costa Rica

On returning from El Salvador, he entered a Ph.D. program in weed science at Oregon State. He continued his work on nutsedge and published for his Ph.D. dissertation two papers on the physiology of control of nutsedge in tropical environments.

After receiving his degree, he accepted employment as extension specialist at Utah State University, and now serves as weed support specialist for an AID project in Somalia.

VI FINANCIAL REVIEW

Table 14 lists expenditures by the AID-OSU weed project, according to broad work areas, during the period April 1, 1976 through May 31, 1983.

Approximately $1 million, or 56% of total expenditures, was spent in directly conducting the overseas research activities of the project. Another 10% was allocated to administrative support, and 5% for research publications. The remaining 30% underwrote research and training conducted in Corvallis and Corvallis support of the overseas research.

Oregon State University contributed an additional $62,715 to the effort, primarily through the provision of research equipment, supplies, and land. Support was also received from a variety of private and public agencies including FAO, the Ford Foundation, and a number of private businesses.

Table 14. AID-Oregon State University Weed Research Contract (AID/ta-C-1295)
Contract Expenditures (April 1, 1976 - May 31, 1983)

category	Corvallis Research	Corvallis publica-tions	Corvallis admini-stration	Southeast Asia (Thailand)	Southeast Asia (Philippines)	Central America (Costa Rica)	Category Totals	Cost Sharing OSU	Cost Sharing Other*
Salaries & wages	232,230	45,030	77,742	50,234	161,610	157,582	724,428	4,500	-0-
Fringe benefits	44,931	10,981	15,310	9,892	35,695	37,226	154,035	1,215	-0-
Indirect costs									
on-campus	133,247	19,635	44,749	-0-	-0-	-0-	197,631	-0-	-0-
off-campus	-0-	-0-	-0-	17,999	77,007	67,341	162,347	-0-	-0-
Sub-totals	133,247	19,635	44,749	17,999	77,007	67,341	359,978	-0-	-0-
Travel & trans-portation	52,687	198	17,562	5,340	100,361	68,665	244,813	9,000	8,000
Other direct costs	34,056	637	11,519	4,210	63,361	61,303	115,086	6,000	3,000
Equipment, vehicles, materials & supplies	10,649	2,659	3,704	2,320	16,109	18,785	54,226	42,000	5,000
Totals	$507,800	79,140	170,586	89,995	454,143	410,902	1,712,566	62,715	16,000

* FAO, Ford Foundation, Chiang Mai University, Private firms.

VII. APPENDIXES

1. Project major publications.
2. Project bibliography: technical papers, presentations, articles.
3. Special publications.
4. Periodic publications.
5. Worldwide distribution of INFOLETTER.
6. Worldwide distribution of publications.
7. IPPC papers distribution.
8. Project personnel roster.

1. Project Major Publications.

FIELD MANUAL FOR WEED CONTROL RESEARCH - L. C. Burrill, J. Cardenas, E. Locatelli

A team of weed scientists compiled this illustrated manual as a practical information source to help conduct successful weed control field research. Sections cover planning, execution, and evaluating weed control field research, as well as reporting results. An extensive list of measures, equivalents, conversions, and rates is included as a time-saving aid. The text also presents a step-by-step method for laying out plots without instruments. Various types of field trials are described with suggestions for minimizing errors and achieving more useful research results. 60 pages, paperback. 1976.

MANUAL DE CAMPO PARA INVESTIGACION EN CONTROL DE MALEZAS - L. C. Burrill, J. Cardenas, E. Locatelli (traduccion por A. I. Locatelli, E. Locatelli)

The Spanish version of Field Manual for Weed Control Research. 64 pages, paperback. 1977.

BIBLIOGRAFIA PARCIAL DE INVESTIGACION SOBRE MALEZAS Y SU CONTROL PARA AMERICA DEL SUR, AMERICA CENTRAL, EL CARIBE Y MEXICO 1942-1976 - complied by H. H. Fisher, E. Locatelli, C. Anderson, and R. L. Chase.

This second edition added new material and offered a slightly reorganized format. 241 pages, paperback. 1978.

A WORLDWIDE CATEGORIZED PARTIAL LISTING FOR MANUFACTURERS OF PESTICIDE APPLICATION EQUIPMENT - edited by A. E. Deutsch.

Firms in more than 30 countries offering any item in nearly 100 categories of equipment were grouped by category and by country along with full address. A bilingual (English-Spanish) introduction and explanation of categorization nomenclature were included. 56 pages, paperpack. 1976.

KNAPSACK SPRAYERS: USE, MAINTENANCE, ACCESSORIES - F. Fraser, L. C. Burrill

The authors employed over 75 photographs and illustrations to describe various functions and, in particular, present details for constructing a variety of multi-nozzle booms to be used in conjunction with manually operated sprayers. Care, maintenance and calibration of sprayers is also included. 31 pages, paperback. 1979.

WEED-CROP COMPETITION, A REVIEW - R. L. Zimdahl

A comprehensive, up-to-date survey of world literature for weeds' competitive influence on crops includes an historical overview and serves as a in-depth reference for relevant research published through 1978. It contains over 700 citations categorized under the headings of competition and studies of weed biology. 198 pages, paperback. 1980.

ECONOMICS OF INTEGRATED PEST MANAGEMENT * An Interpretive Review of the Literature - B. A. McCarl

The existing body of literature dealing with the various economic aspects of integrated pest management was reviewed and appraised. An extensive bibliography is included. 142 pages, paperback. 1981.

SMALL FARM WEED CONTROL * An Annotated Bibliography - J. A. F. Compton

In conjunction with the Intermediate Technology Development Group in the U.K., the project prepared a comprehensive overview of print materials concerned with weed control methods, equipment, and strategies for small farms in less developed countries. 170 pages, paperback. 1982.

ECONOMIC RETURNS TO INVESTMENT IN CONTROL OF MIMOSA PIGRA IN THAILAND - G. L. Robert

A study was conducted in northwest Thailand (Chiang Mai) to assess the parameters for when, or when not, to invest in controling the noxious plant, Mimosa pigra. Also, a determination was developed for the most economic control methods to utilize. 247 pages, paperback. 1982.

CROP PRODUCTION USING COVER CROPS AND SODS AS LIVING MULCHES - Edited by J. C. Miller and S. M. Bell.

Proceedings of a workshop held in Corvallis, Oregon, were published in cooperation with an on-campus coordinating group. 123 pages, paperback. 1982.

NO-TILLAGE CROP PRODUCTION IN THE TROPICS - Edited by I. O. Akobundu and A. E. Deutsch.

The project published the proceedings of an international symposium held in Monrovia, Liberia, in 1981. The publication was a collaborative effort of the project, the International Weed Science Society, and the West African Weed Science Society. 235 pages, paperbound. 1983.

MIMOSA PIGRA MANAGEMENT - Edited by G. L. Robert and D. H. Habeck

This publication presented the proceedings of an international symposium held in Chiang Mai, Thailand, in 1982. The event was organized by the International Plant Protection Center in cooperation with several Thai governmental agencies. 140 pages, paperback. 1983.

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Periodic Report, 1978-79. 56 pages.

Annual Report, 1979-80. 52 pages.

Annual Report, 1980-81. 64 pages.

5. Worldwide Distribution of INFOLETTER

country	recipients as of Dec. 1975	Apr. 1978	May 1981	May 1983
Abu Dhabi	1	1	1	1
Aden	1	1	1	
Afghanistan	15	13	12	1
Algeria	2	3	3	6
Angola	2	2	1	1
Antigua	2	2	2	2
Arab Rep. of Egypt	9	11	16	20
Argentina	213	131	158	173
Australia	59	63	87	106
Austria	5	5	5	6
Bahamas	1	1	1	2
Bangladesh	4	4	8	15
Barbados	2	2	3	2
Basseterre	-	-	1	1
Belgium	11	12	29	28
Belize	8	8	6	8
Benin	1	1	2	1
Bermuda	1	1	1	1
Bolivia	21	29	28	28
Botswana	3	3	4	8
Brasil	183	186	192	203
Brunei	3	3	3	3
Bulgaria	2	2	2	2
Burma	3	3	4	7
Burundi	-	-	2	3
Cameroon	4	5	7	11
Canada	101	108	138	147
Canary Is.	1	1	1	1
Cape Verde Is.	-	1	1	2
Caroline Is.	1	-	-	-
Cayman Is.	-	1	1	1
Cent. African Rep.	1	1	1	1
Chad	3	5	4	3
Chile	37	37	45	46
People's Rep. of China	-	1	4	7

country	recipients as of Dec. 1975	Apr. 1978	May 1981	May 1983
Colombia	166	92	97	94
Comores	2	2	2	2
Cook Is.	-	-	-	2
Costa Rica	54	68	76	83
Cuba	1	1	1	3
Cyprus	3	2	4	6
Czechoslovakia	8	10	12	12
Denmark	9	10	20	21
Djbouti	-	1	1	1
Dominica	-	-	-	1
Dominican Rep.	10	11	15	15
Ecuador	45	45	49	53
El Salvador	18	10	11	12
England	113	120	169	187
Ethiopia	20	25	27	31
Fiji	4	3	5	11
Finland	8	9	18	18
France	22	27	74	81
Gabon	1	8	1	1
Gambia	2	5	4	4
Germany (East)	2	5	1	1
Germany (West)	38	41	59	58
Ghana	22	24	31	40
Greece	16	24	27	27
Grenada	-	-	-	1
Guatemala	29	8	15	17
Guinea-Bissau	1	1	1	1
Guyana	2	3	4	5
Haiti	3	3	3	3
Honduras	34	18	21	29
Hong Kong	4	4	5	3
Hungary	4	4	8	8
India	161	183	232	281
Indonesia	88	86	97	119
Iran	10	12	12	11
Iraq	2	3	3	3

country	recipients as of Dec. 1975	Apr. 1978	May 1981	May 1983
Ireland	7	7	7	8
Israel	18	18	21	25
Italy	19	27	32	35
Ivory Coast	4	5	9	6
Jamaica	11	11	10	11
Japan	52	53	58	61
Jordan	7	8	8	8
Kenya	28	28	35	44
Korea	12	15	13	13
Kuwait	-	-	2	2
Laos	7	7	7	7
Lebanon	8	7	6	6
Lesotho	2	2	3	3
Liberia	7	8	7	12
Libya	1	2	5	5
Malagasay Rep.	1	1	1	1
Malawi	5	6	7	13
Malaysia	56	59	65	72
Mali	1	2	3	4
Malta	3	3	4	4
Mariana Is.	1	-	-	-
Mauritania	-	2	2	3
Mauritius	2	2	3	3
Mexico	126	56	69	76
Morocco	3	3	3	4
Montserrat	-	-	1	1
Mozambique	2	2	2	3
Nepal	-	2	2	6
Netherlands	15	17	36	40
New Caledonia	4	4	4	4
New Hebrides	2	2	2	2
New Zealand	21	30	26	30
Nicaragua	29	16	19	12
Niger	-	1	3	3
Nigeria	28	38	55	70
Norway	10	10	12	12

country	recipients as of Dec. 1975	Apr. 1978	May 1981	May 1983
Pacific Is.	2	3	2	2
Pakistan	14	21	20	22
Panama	26	15	17	18
Papua New Guinea	15	17	14	15
Paraguay	9	10	11	11
Peru	74	73	77	77
Philippines	67	139	198	207
Poland	9	9	9	10
Portugal	5	7	11	14
Qatar	-	-	-	2
Romania	2	2	4	4
St. Kitts	-	1	3	3
St. Lucia	1	-	-	2
St. Vincent	-	-	2	2
Samoa	1	-	-	-
Saudi Arabia	6	6	6	8
Scotland	4	4	4	7
Senegal	11	18	22	25
Seychelle Is.	1	2	1	1
Sierra Leone	4	4	6	5
Singapore	14	13	10	11
Solomon Is.	2	2	3	4
Somalia	-	1	1	1
South Africa	-	2	5	7
South Vietnam	11	11	7	7
Spain	9	14	25	26
Sri Lanka	11	15	18	26
Sudan	9	13	17	28
Surinam	4	4	6	2
Swaziland	2	2	2	4
Sweden	13	16	28	27
Switzerland	27	26	28	28
Syria	2	6	9	6
Tahiti	3	3	3	3
Taiwan R.O.C.	18	8	17	18
Tanzania	12	13	17	16

country	recipients as of Dec. 1975	Apr. 1978	May 1981	May 1983
Thailand	40	45	60	90
Togo	1	1	2	3
Trinidad and Tobago	15	17	21	25
Trucial States	1	1	1	1
Tunisia	4	4	5	6
Turkey	16	15	23	23
Uganda	5	5	5	6
Upper Volta	2	5	6	7
Uruguay	18	22	23	24
United States*	1,213	1,356	1,661	1,807
U.S.S.R.	4	4	4	6
Venezuela	50	53	59	62
Western Samoa	6	7	9	13
Yemen	-	1	3	2
Yugoslavia	5	6	8	10
Zaire	3	3	4	4
Zambia	8	7	10	9
Zimbabwe	-	-	1	2
TOTAL	3,930	4,069	4,931	5,439

*Includes Guam - 5, Canal Zone - 3, and numerous AID and other U.S. government employes overseas who receive their mail through Washington or APOs.

6. Worldwide Distribution of Publications

Identification Key

symbol	title
Ag	Aquatic Plant Bibliographies.
Bi	Bibliografia Parcial de Investigacion sobre Malezas y su Control para America del Sur, America Central, El Caribe y Mexico, 1942-1976.
Ca	Manual de Campo para Investigacion en Control de Malezas.
FM	Field Manual for Weed Control Research.
IPM	Economics of Integrated Pest Management.
KS	Knapsack Sprayers: Use, Maintenance, Accessories.
SF	Small Farm Weed Control: An Annotated Bibliography.
No	No-tillage Crop Production in the Tropics.
Mu	Crop Production Using Cover Crops and Sods as Living Mulches.
Tr	Algunos "Trucos" en Estadistica.
WC	Weed-Crop Competition.
WS	Semillas de Malezas Tropicales I y II / Tropical Weed Seeds I and II.

For: 5/76 - 6/83

country	Aq	Bi	Ca	FM	IPM	KS	SF	No	Mu	Tr	WC	WS
Afghanistan	-	-	-	1	-	-	-	-	1	-	2	10
Algeria	-	-	1	3	1	1	1	-	-	1	1	2
Angola	-	1	-	1	-	-	-	-	-	1	-	-
Antiqua	-	1	-	1	-	1	-	-	-	-	-	1
Arabian Gulf	-	1	-	1	-	1	-	-	-	-	-	-
Argentina	33	44	214	21	5	16	8	-	-	41	28	64
Australia	33	-	6	41	1	19	1	1	1	-	29	19
Austria	9	-	-	1	-	-	-	-	-	-	3	-
Bahamas	-	-	-	2	-	2	-	-	-	-	-	2
Bangladesh	3	-	1	7	2	5	3	-	-	-	5	3
Barbados	-	1	1	5	-	1	1	-	-	1	1	3
Belgium	6	-	-	5	-	-	-	-	-	1	1	-
Belize	-	11	17	10	1	2	1	-	-	2	2	18
Benin	-	1	-	1	-	1	-	1	-	-	1	1
Bhutan	-	-	-	-	1	2	-	-	-	-	-	-
Bolivia	-	31	33	9	2	1	1	1	-	14	2	38
Botswana	3	1	-	6	-	-	2	-	-	-	1	2
Brasil	15	26	45	48	9	8	6	6	-	40	30	105
Brunei	-	-	-	-	1	-	1	-	-	-	-	-
Burma	-	-	2	-	-	-	-	-	-	1	1	-
Burundi	-	-	2	-	1	1	-	-	-	2	-	-
Cameroon	-	1	-	2	-	3	-	-	-	-	1	1
Cayman Is.	-	-	-	-	1	1	-	-	-	-	1	1
Canada	42	2	4	71	14	15	2	-	-	2	60	4
Chad	-	-	-	1	-	-	-	-	-	-	-	-
Chile	-	12	14	4	-	2	4	-	-	12	14	9
Colombia	3	22	47	16	9	4	2	1	1	35	10	93
Costa Rica	-	43	59	84	9	12	8	3	3	53	22	165
Cyprus	-	1	-	2	-	1	1	-	-	-	3	-
Czechoslovakia	15	-	-	3	-	-	-	-	-	-	-	-
Denmark	3	-	1	4	-	2	-	-	-	-	3	-
Dominican Rep.	-	11	15	5	2	1	3	-	-	5	5	3
East Germany	9	-	-	1	-	-	-	-	-	-	1	-
Ecuador	-	49	70	6	1	5	2	-	-	23	6	99
Egypt	15	1	1	2	-	1	1	-	-	1	3	1
El Salvador	-	10	15	7	-	2	-	-	-	16	2	19

country	Aq	Bi	Ca	FM	IPM	KS	SF	No	Mu	Tr	WC	WS
England	54	6	4	71	8	35	132	9	9	2	53	11
Ethiopia	3	-	-	12	3	2	3	1	1	-	8	4
Fiji	-	1	-	8	2	5	2	-	-	-	6	3
Finland	6	-	-	2	-	-	-	-	-	-	-	-
France	39	2	1	10	2	2	3	-	-	1	9	-
Gambia	-	-	-	3	-	1	1	-	-	-	1	3
Ghana	12	1	-	9	2	7	5	1	-	-	12	5
Greece	-	2	-	10	1	1	-	-	-	-	2	4
Grenada	-	-	1	-	-	-	-	-	-	-	-	-
Guadeloupe	-	1	-	1	-	-	1	-	-	1	-	1
Guatemala	-	9	16	12	-	2	-	-	-	5	2	14
Guyana	6	-	-	6	1	1	2	-	-	-	1	1
Haiti	-	-	-	-	1	-	-	-	-	-	-	-
Honduras	3	17	38	14	2	4	4	-	1	17	3	53
Hong Kong	-	-	-	1	-	1	-	-	-	-	-	-
Hungary	9	-	-	1	-	-	-	-	-	-	1	4
India	114	16	1	120	17	27	26	4	3	11	144	56
Indonesia	-	4	4	37	11	11	10	2	1	7	20	14
Iran	-	-	-	5	-	-	-	-	-	-	1	-
Iraq	-	-	-	2	-	-	-	-	-	-	-	2
Ireland	-	-	-	5	-	-	-	-	-	-	-	-
Israel	18	-	-	8	2	1	-	1	1	2	8	3
Italy	9	3	3	13	-	1	-	1	-	2	3	1
Ivory Coast	-	1	1	3	1	-	-	-	-	-	2	1
Jamica	3	2	-	4	-	5	-	-	-	-	1	4
Japan	30	-	-	6	-	1	1	1	-	1	2	1
Jordan	-	-	-	2	-	1	1	-	-	-	-	-
Kenya	-	-	-	13	2	7	2	2	1	-	10	1
Korea	6	2	-	2	-	2	-	-	-	-	2	2
Kuwait	-	-	-	1	-	-	-	-	-	-	-	-
Lebanon	-	-	-	4	-	1	-	-	-	-	3	3
Lesotho	-	1	1	2	-	1	-	-	-	1	1	1
Liberia	-	1	-	7	1	2	1	-	-	-	3	3
Libya	-	-	-	2	-	-	-	-	-	-	-	-
Malaysia	3	2	1	41	5	7	3	-	-	1	21	10
Malawi	-	1	-	5	1	2	1	-	-	-	1	1
Mali	-	-	-	1	-	1	1	-	-	-	-	-
Mauritus	-	-	-	-	-	-	1	-	-	-	-	-
Morocco	-	-	-	1	1	1	-	-	-	-	1	-

country	Aq	Bi	Ca	FM	IPM	KS	SF	No	Mu	Tr	WC	WS
Mozambique	3	-	2	2	1	1	-	-	-	2	1	1
Mexico	18	67	480	179	5	50	5	1	1	35	39	91
Namibia	-	-	-	-	-	-	-	-	-	-	-	-
Nepal	-	-	-	3	-	1	1	-	-	-	1	3
Netherlands	27	-	1	13	1	1	1	1	1	2	9	6
New Zealand	30	-	-	17	-	3	2	-	1	-	5	-
Nicaraqua	-	23	53	10	4	10	2	1	2	18	6	37
Niger	-	-	-	1	-	-	-	-	-	-	-	-
Nigeria	3	2	-	22	4	5	10	50	2	1	26	6
Norway	-	-	-	1	-	-	-	-	-	-	1	-
Pakistan	-	-	-	54	1	28	3	1	1	1	12	2
Panama	-	25	34	4	-	-	-	-	-	5	1	30
Papua New Guinea	-	-	-	3	-	1	1	-	-	-	2	-
Paraquay	-	19	25	1	1	-	[illegible]	-	-	1	3	19
Peru	6	43	61	38	3	6	4	1	1	16	5	41
Philippines	6	25	12	163	16	24	38	3	7	27	56	590
Poland	36	-	-	-	1	-	-	-	-	-	1	-
Portugal	-	1	2	-	1	2	-	-	-	2	5	1
Romania	-	-	-	1	-	-	-	-	-	-	-	-
St. Helena	-	-	-	-	-	1	1	-	-	-	-	-
St. Kitts	-	-	-	1	-	-	-	-	-	-	-	-
St. Lucia	3	1	-	3	2	2	-	-	1	-	4	1
St. Vincent	-	-	-	1	-	-	-	-	-	-	-	1
Saudi Arabia	-	-	-	1	-	-	-	-	-	1	-	2
Sierra Leone	-	-	-	5	-	1	-	-	-	-	2	2
Senegal	-	-	-	9	1	4	1	1	-	-	2	-
Singapore	-	1	-	5	-	1	-	-	-	-	-	3
Spain	9	1	5	3	-	4	-	-	-	4	5	3
South Africa	15	-	-	7	2	2	1	1	-	1	10	1
South Pacific Is.		-	-	7	1	3	-	-	-	-	1	-
Sri Lanka	6	-	-	16	6	7	2	1	1	-	10	2
Sudan	3	-	-	7	3	2	1	-	-	-	4	4
Surinam	-	1	-	-	-	-	1	-	-	1	-	1
Swaziland	-	-	-	2	-	-	1	-	-	-	-	-
Sweden	6	-	-	2	-	-	-	-	-	-	1	-
Switzerland	12	-	-	122	-	12	-	-	-	-	18	1
Syria	-	-	-	1	-	2	1	1	1	-	2	10
Taiwan, R.O.C.	9	-	-	8	3	4	1	1	1	1	9	2
Tanzania	-	1	-	8	-	1	-	-	-	-	6	3

country	Aq	Bi	Ca	FM	IPM	KS	SF	No	Mu	Tr	WC	WS
Thailand	6	3	1	29	5	16	5	2	1	-	17	12
Togo	-	-	-	1	-	-	-	-	-	-	-	-
Trinidad	-	4	1	14	1	7	2	-	-	3	7	21
Turkey	-	5	-	13	1	7	3	-	-	-	10	3
Uganda	-	-	-	4	-	1	2	-	-	-	3	3
Upper Volta	-	-	-	1	-	-	1	-	-	-	-	1
Uruguay	-	7	11	3	-	-	-	-	-	7	4	8
United States	633	627	757	1104	174	630	176	25	27	598	1104	159
USSR	9	-	-	-	-	-	-	-	-	-	1	-
Venezuela	-	10	24	10	8	3	2	-	-	14	12	21
Vietnam	-	1	-	1	-	1	-	-	-	-	-	1
West Germany	15	1	2	33	1	-	1	1	1	1	24	5
Western Samoa	-	1	-	3	2	2	1	-	-	-	4	6
Yemen	-	-	-	1	-	1	-	-	-	-	1	-
Yugoslavia	9	-	-	2	-	1	-	-	-	-	1	1
Zambia	-	-	-	3	2	2	3	-	-	-	4	1
Zanzibar	-	-	-	-	-	-	-	-	-	-	1	-
Zimbabwe	3	-	-	2	2	2	1	-	-	-	4	-

7. IPPC Papers Distribution

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1975, The beautiful blue devil, N. Vietmeyer, NATURAL HISTORY, 1975.	470
1976, Approaches to weed control in cropping systems, D.L. Plucknett et. al., Cropping Systems Symposium at the Int'l. Rice Research Institute, 1976.	469
1978, Controlled drop application - what does it all mean?, G. Cussans and W. Taylor, ARABLE FARMING, 1978.	344
1978, Selecting appropriate weed control systems for developing countries, D.L. Young et. al., WEED SCIENCE, 1978.	656
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1982, Weed control in integrated crop protection, W.H. Vanden Born, Agriculture & Forestry Bulletin, vol. 5, no. 3, 1982.	11
1983, Pesticide packaging: there is room for improvement, Brian Pickering, Shell Agriculture, September 1982.	8

8. Project Personnel Roster

location	position	FTE	
Corvallis	director, agric. economist	.22	
	senior weed scientist	.25	
	communications/admin.	.20	
	weed scientist	.25	
	agric. economist	.33	
	subtotal		1.25
	classified	2.20	
	Total		3.45
Costa Rica	weed scientist	.5	
	agric. economist	1.0	
	Total		1.50
Philippines	weed scientist	.50	
	weed scientist	.50	
	agric. economist	1.0	
	Total		2.00
Thailand	agric. economist	1.0	
	Total		1.00

Total professional	5.75	
Total classified	2.20	
GRAND TOTAL		7.95