UNIVERSITY OF PUERTO RICO
MAYAGUEZ CAMPUS
COLLEGE OF AGRICULTURAL SCIENCES
AGRICULTURAL EXPERIMENT STATION

ANNUAL REPORT OF ACCOMPLISHMENTS AND RESULTS

Planning Option: This Annual Report of Accomplishments and Results is prepared for our Institution's individual functions, just as our 1999-2004 Five Year Plan of Work.

Reporting Period: October 1, 1999 to September 30, 2000.

Due Date: March 1, 2001.

Certification: Dr. Ernesto O. Riquelme
Acting Dean and Director, CAS

ANNUAL REPORT OF ACCOMPLISHMENTS AND RESULTS

General Overview

As stated in previous reports, the mission of the University of Puerto Rico Agricultural Experiment Station (AES) is to conduct the basic and applied research needed to achieve an economically viable agricultural sector, to strengthen the industries that process agricultural raw materials, and to stimulate rural development, while conserving our natural resources and the environment. AES is involved, together with the faculty of the College of Agricultural Sciences (Fac) and the Agricultural Extension Service (PRAES), in the ongoing development of a strategic plan defining our programmatic efforts.

Five principal goals, consonant with federal and local priorities, drive our research program:

1. To develop technology for achieving a sustainable agricultural production system that is socioeconomically viable and competitive.
2. To develop technology for processing traditional and new agricultural products and for achieving a safe food and fiber system.
3. To provide direct services and technical expertise to farmers, agroindustries, and public agencies that lack the specialized personnel and research facilities present at AES.
4. To develop agricultural technology that is compatible with the preservation of our natural resources and the environment.
5. To provide the socioeconomic research needed to formulate alternatives that can potentially improve economic opportunities and the quality of life in rural areas.

Most of our research effort is concentrated in goals one and four. The research program is organized in eleven commodities: vegetable crops, fruit crops, root and tuber crops, plantains and bananas, coffee, basic grains, sugar cane, ornamental crops, meat production, milk production, and environment and natural resources. There is a leader for each commodity program, all of them under the direction of the Assistant Deputy Director for Research. Each commodity group meets at least once a year.

Funding for AES research program is provided by several sources. USDA funding is crucial to the overall research budget with formula funds (Hatch regular, Hatch regional and McIntire Stennis) supporting base research, and NRI Competitive grants and Special grants supporting targeted research areas. Special grants such as Tropical and Subtropical Agriculture Research (T-Star) Program are of great importance to us. State funding is also a major source of funding to us, as well as extramural research grants and contracts, such as those from the Natural Resources Conservation Service, Environmental Protection Agency, USDA-ARS, SARE-ACE, BARD, Puerto Rico Department of Agriculture, Puerto Rico Department of Natural Resources, Puerto Rico Science and Technology Board, and other, often non-local Universities.

Three notable examples of these multinstitutional, often multistate linkages and partnerships (Appendix 2 of the 1999-2004 Five Year Plan of Work lists 41 of them) may be Dr. James

Beaver's bean projects dealing with Golden Mosaic Resistance, in conjunction with various organizations, among them, USDA - Tropical Agriculture Research Station; The University of Nebraska; the *Centro de Investigaciones Agropecuarias del Suroeste*, San Juan de la Maguana, Dominican Republic; Michigan State University, and others; Professor Edwin Abreu's project in biological control of aquatic weeds, together with the Puerto Rico Department of Natural Resources and the US Army Corps of Engineers; and Dr. Victor Snyder's post tillage soil structure and pore space dynamics project, in conjunction with Utah State University and the Agricultural Research Organization of Israel.

Other than this, AES participates and cosponsor international congresses and scientific meetings where knowledge is spread, such as that of ACORBAT (*Asociación para la Cooperación en Investigaciones Bananeras en el Caribe y América Tropical*), whose XIV meeting took place in San Juan, Puerto Rico, from July 31 to August 4, 2000, and that of the PCCMCA (*Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales*), held from May 1 to 5, 2000, also in San Juan, Puerto Rico; and local scientific congresses, such as that of SOPCA (*Sociedad Puertorriqueña de Ciencias Agrícolas*), which met November 30, 1999. AES also sponsors a multiplicity of seminars and other presentations by its scientific personnel and outside scientists, featured throughout the year (see Appendix I).

Planned Programs:

Goal I. *An agricultural system that is highly competitive in the global economy.*

Overview

Agriculture is a sector of strategic importance to Puerto Rico both in terms of its present and its potential contribution to the economy. While it is the smallest of the major economic sectors, its broader economic impact is significant, given the high multiplier effect of its activities. Puerto Rico has a high import bill for food, much of which could be competitively produced locally if appropriate technology is devised, disseminated among farmers, and emerging problems are researched to formulate viable solutions.

Goal one, which utilizes about 81% of our human resources, is by far the largest in the Agricultural Experiment Station of the University of Puerto Rico (UPR). Around 70% of our research projects (both federally and otherwise funded) are ascribed to this goal. Several examples of them are presented and discussed next. These projects are in line with the furtherance of agricultural production, the long-term critical issue being targeted by this goal; beyond that, each research project has been evaluated according to its short and intermediate term critical issue (s). The funds and FTE disclosed are from October 1, 1999 to September 30, 2000.

AES has an ongoing project, H-94 (S-9) devoted to the evaluation of promising new crops and new varieties of crops. This is covered under the output indicator, *New Germplasm is evaluated*. Under this project, through the years, many new varieties have been introduced

and evaluated, and some are currently used by local farmers. This is a continuous, long term work. As will be explained shortly, this year was no exception.

Beyond this, pests are a continuous problem that needs to be addressed. This is partly covered by the output indicator *New integrated pest management practices are developed* and by the outcome indicators *Resistance to certain pests and diseases is increased* and *Crop production and management is improved.* Several pests within several crops, and several pesticides, were evaluated this year. Different to plant germoplasm, this area of work is addressed by several projects.

Animal production and efficiency is an important area as well, which was covered by the output indicator *New feeding and health management practices are developed*, and by the outcome indicator *Livestock production and management is improved.* This area of work is also addressed by several projects.

Finally, irrigation and fertilization are most important aspects of tropical agriculture, along with pest control, and were foresaw in the output indicator, *New fertilization and irrigation practices are developed*, and in the outcome indicators, *Crop production and management is improved* and *Local crop production is increased.*

It is clear that AES runs a multiplicity of research projects that could as well have been used as examples of work done under this goal (or, for that matter, the second, forth, or fifth goals). The purpose at this time is to show examples of how the different problems, situations or needs, what CSREES calls key themes, are tackled by our Institution.

Hatch funds under this goal: **$3,379,643.00**
FTE: 40.1
CBAG funds: **$141,804.00** FTE: 2.5
SGF: **$7,135.00** FTE: 0[1]
Animal Health: **$7,634.00** FTE: 0.5

I. Key Theme - Plant Germplasm

A. Under project H-94 (S-9), Plant Genetic Resource Conservation and Utilization, several orchards are maintained throughout the Island. A replicated guava planting consisting of 14 accessions was established at Juana Díaz in 1998, and data are being collected on fruit production, tree height and canopy volume. Established orchards of guava (54 accessions), avocado (32 accessions) and soursop (7 accessions) were maintained at Juana Díaz. Seventeen plantain and 26 banana cultivars were maintained in a field germplasm collection at Corozal. Four exotic banana cultivars ('Niño Enano', 'Niño Orocovis', 'Manzano' and 'Yamgambi') were evaluated in the field at Corozal. The yield of 'Yamgambi'

[1] The scientist in charge of this project, (SGF 11 – 97-34135-4777), Dr. F. Pérez, is a member of the Faculty of Agriculture, not of AES; therefore, technically, the FTE is zero.

was superior to the other three cultivars, producing an average of 119 fruits per bunch, with a mean weight of 83 grams per fruit. Field germplasm collections of yam (30 accessions), cassava (27 accessions) and sweet potato (18 accessions) were maintained at Corozal. Seventy-five tanier accessions were maintained in the field at Isabela. An evaluation of eight cassava cultivars introduced from Colombia was completed. The highest yielder was C.M. 3311, with 19,318 kg/ha of marketable roots at 7 months from planting. C.M. 3311 also showed less mite damage than the other cultivars. A germplasm collection consisting of 70 coffee accessions was maintained at Adjuntas. The evaluation of 'Washington Navel' orange on 'Cleopatra', 'Naronja', 'Swingle' and 'Sun Chu Sha' rootstocks at Corozal and Isabela showed no significant differences for fruit number per tree, fruit weight or brix. No significant differences in fruit number per tree were observed for chironja on four rootstocks. 'Orlando' tangelo produced more fruits per tree at Corozal than at Adjuntas on four rootstocks. A collection of 34 Spanish lime accessions at Juana Díaz was evaluated for morphological and fruit quality characters for the third year. New projects include the evaluation of forage legume Cratilia argentae accessions CIAT 18668 and CIAT 18516, and characterization of avocado, sweet cherry pepper, and "Mayagüezano" mango germplasm.

B. Impact - Several promising Spanish lime genotypes have been identified in the collection of 34 genotypes at Juana Díaz; these could result in improved production and consumption of this minor fruit. Higher yielding cultivars of banana ('Yamgambi') and cassava (C.M. 3311) identified in this research can increase profits for farmers; also, the mite tolerance observed in cassava accession C.M. 3311 could reduce pesticide usage. Information gained from germplasm evaluation can be used by researchers and farmers to improve agricultural production.

C. Source of Federal Funds - Hatch funds: **$385,132.00** (under project S-9, known locally as H-94). FTE: 4.9.

D. Scope of Impact: State Specific PR

II. Key Theme - Plant Health

A. Three projects of ours are examples of research dealing with this topic. Projects H-216 (insects), H-369 (bacteria) and H-379 (virus) addressed this key theme.

As for insect control practices, three avocado trials were established during the year to accomplish the IR-4 protocols for magnitude of residue of imidacloprid on avocado. Residue samples were taken and sent to residue lab. Following GLP techniques. The field Data Books are in process to be completed and submitted during 2001. Another trial for magnitude of residue of buprofezin on avocado was conducted. Samples were taken and the report is in process.

An efficacy trial was established on mango testing Buprofezin (Applaud) 70WP, Cyhanothrin (Baythroid) 2, and Imidacloprid (Admire) 2F for insect control. This trial is in progress.

Three Fipronil magnitude of residue trials (IR-4) were sampled and samples sent to the residue laboratory following GLP techniques. The field Data Books are in process to be completed and submitted during 2001.

As for bacteria, the following were found on both tomato and pepper: *Xanthomonas campestris* pv. *vesicatoria*, *Clavibacter michiganense, X. maltophilia, Agrobacterium tumefaciens, and Pseudomonas putida*. Bacteria only on pepper were *Pseudomonas aeuriginosa, P. citronellois, Agrobacterium rizogenes, Enterobacter cloacae* and *Flavobacterium indologenes*. Bacteria only on tomato were *Pseudomonas fulva*, *Acinetobacter calcoacet/baumannii* and *Escherichia vulneris*.

Important bacterial population on *Anthurium* leaves are gram positives (89%) and 10.5% for negatives on the control plants. Best treatments to control the bacterial blight disease on anthurium were PhysanB and CaCl2B with 81.7% and 72.8% gram positives, respectively.

Bacterial epiphytes from apparently healthy mango leaves (*Mangifera indica* L.) were identified. Gram positives were: *Clavibacter michiganense, Curtobacterium pusillum, C. luteum, C. flacumfaciens pv. flacumfaciens, and C. flacumfaciens pv. Oortii.* Gram negative were*: Acinetobacter radioresistens, Enterobacter agglomerans, Klebsiella pneumoneae, Pantoea agglomerans, Pasteurella caballi, Pseudomonas putida, Sphingomonas paucimobilis* and *Xanthomonas oryzae* pv. *Oryzae*. The mango cultivars studied were Austin, Edward, D. Hayden, Hayden, Hayden, Kent, Keitt, Palmer, Parvin, and Piñero. Important bacteria pathogenic on mango were not detected.

As for viruses, 166 trees of one of the nurseries in the Adjuntas Agricultural Experiment Substation were analyzed for citrus tristeza virus (CTV). Seventy-six percent (76%) of the trees were found positive for severe strains of the virus in ELISA (enzyme-linked immunosorbent assays) using the severe detector monoclonal antibody 13 (MCA 13). Twenty-three percent (23%) of the trees were CTV mild and 1% (2/166) were healthy. In a tangerine collection (47 trees) in the same substation 19.1 % of the trees were MCA 13 positive, 42.6 % were CTV mild, 10.6 % were found CTV free, and 27.7% (14/47) of the trees were dead. During a visit to the Ozonas citrus farm in Adjuntas in the company of Dr. Chester Roistacher from the University of California, Riverside, the following conditions were observed: a general severe decline of Valencia orange trees on Cleopatra mandarin rootstock; a leaf curling condition known as 'frenching' suggesting the very severe types of tristeza in Peru and South Africa; lesions on the trunk of a Valencia orange tree strongly indicative of the presence of psorosis; and a very severe decline of a 9 to 10 year old Valencia orange tree on Carrizo citrange

rootstock that suggests exocortis. Obvious recommendation is indexing for all these types of maladies. The report on this visit will be presented as part of a proposal for the establishment of a citrus certification program in the island.

B. Impact - Two new insecticides (Imidacloprid and Buprofezin) were studied to determine the magnitude of residue in order to obtain tolerance and forwarding a use label in the control of the major insect pests in the avocado-mango-papaya group in Puerto Rico.

A new insecticide (Fipronil) was studied to determine the magnitude of residue in order to obtain tolerance and forwarding a use label in the control of the major insect pest of the plantain and banana in Puerto Rico. An alternative against the carbamate and organophosphates insecticides is being used in Puerto Rico.

Seasonal and geographical distribution of main bacterial diseases have been partialy determined. Knowlegde about bacterial diversity able to colonize the niche of pathogens and survival is important to control diseases. This is the first study conducted on bacterial epiphytes on mango under tropical conditions. Black spot is an endemic bacterial disease on mango on main production areas such as Asia, Africa and Brazil.

The monitoring of CTV in citrus farms helps to identify potentially destructive severe strains. Potentially useful strains that can be used for cross protection can also be identified. Those strains could be used in a citrus certification program to ensure that the released plant material is infected with appropriate strains.

C. Source of Federal Funds - Hatch funds: Under project H-216, **$287,908.00**; project H-369, **$205,602.00**; and project H-379, **$76,001.00.** FTE: For H-216, 3.4.; H-369, 2.1; and H-379, 1.3.

D. Scope of Impact: State Specific PR.

III. Key Theme - Animal Production Efficiency

A. Two projects address this key theme: H- 375 and H 380.

Forty-seven (47) Holstein (H), Zebu (Z), Senepol (S), and Z and S x H crossbred (XH) young bulls rotationally grazed 39.5 acres of an association of Stargrass *(Cynodon nlemfuensis Vanderyst var. nlemfuensis),* Para grass *(Brachiaria purpurascens Henr.),* and Caribgrass *(Eriochloa polystachya H.B.K.)* pastures. stocking rate was fixed throughout the trials and pastures were fertilized in November and May of each year with a 15-5-10 formula at a rate of 800 lb/acre per year. After two complete grazing trials HX bulls had significantly higher ($P<0.05$) average daily gains (ADG) and final weights (FW) than the S, H and Z bulls (11.39, 1195.6 vs. 1.27, 1139.6; 1.20, 1114.0, and 1.10 lb/day, respectively). Differences in ADG and FW between S and Z bulls were also significant ($P<0.05$). First trial offal components green hide, head, feet, liver, lungs, heart and kidneys represented 7.06, 3.52, 2.07, 1.15, 1.12, .31, and .19% of the H; 7.88, 2.49, 1.78, .74, .80, .22 and .12% of the Z; 8.76, 3.13, 2.11, 1.06, 1.07, .32 and .17% of the S; and 8.12, 3.17, 2.16, 1.03, 1.04, .29, and .17% of the HX processing weight. Dressing percentages ranged from 54.28% in the H to 55.03% in the HX. Loin eye area was 11.81, 11.78, 10.92 and 10.05 square inches for the HX, Z, H and S bulls, respectively. Percentages of muscle, bone, and trimming plus fat/connective tissue from the left hindquarter were 64.51, 21.41 and 14.25% for the H; 65.67, 20.77 and 14.82% for the HX bulls; 66.10, 20.60 and 16.09% for the S; and 64.60, 19.55 and 21.90% for the Z. Z and S bulls showed muscle to bone ratios of 3.29 and 3.21, while the H crossbred and purebred bulls had ratios of 3.15 and 3.01, respectively.

After two breeding seasons Senepol x Charbray (SxCh), Senepol (S), and Charbray (Ch) cows mated to S and Ch bulls showed the following pregnancy and calving rates, 95.6-92.8%, 87.3-87.3%, and 81.2-73.9%, respectively. Weaning weights followed the same trend with de SxCh weaning 89.2% of their calves, the Senepol 85.6% and the Charbray 73.7%. Calving intervals were lower for the Ch (359 days) and SxCh dams (365.5 days) than for the S (396.3 days). As expected, weight loss during lactation was greater in the SxCh and S groups than the Ch (53.7 and 56.7 vs. 27.8 lb/cow/lactation period). Birth weights for male and female calves were very similar for the SxCh, S, and Ch cows (male calves 74.1, 72.3 and 68.1 lb; female calves 74.4, 72.7, and 71.05 lb, respectively). Efficiency ratios of calf 205 days adjusted weaning weight/dam weight (CAWW/DW) and CAWW/DW x weaning rate favored the SxCh crossbred dams over the Ch and S (52.5%; 45.9% vs. 46.0%; 33.1%, and 44.0%; 37.4%, respectively). Male calves 205 days adjusted weaning weights were higher in the SxCh (500.1 lb) and Ch (501.6 lb) females than in the S (447.2 lb) cows. Female calves 205 days adjusted weaning weights were also lower for the Senepol cows. Charbray sired male and female calves were heavier at birth (79.6; 74.37 lb) and at 205 days adjusted weaning weight (453.8; 414.23 lb) than those sired by Senepol bulls (69.9; 63.07 and 439.4; 390.95 lb, respectively). The male and female calves from the Ch x SxCh cows and the Ch calves were the heaviest of all breed of sire and breed of cow combinations.

B. Impact - The utilization of 10,000 (1/3 of bull calves produced by the local dairy industry) purebred or crossbred Holstein bull calves for beef would increase local beef production by 15% (6,270,000 lbs of beef with a cash value of $6.6 million) and reduce beef imports, resulting in the infusion of $6.6 million into the local economy that would otherwise be used to purchase beef from other countries.

In commercial cow-calf operations income is determine by the number of calves produced and their weaning weights. The first step to increase income in the beef cow enterprise is to improve the reproductive efficiency of the herd.

C. Source of Federal Funds - Hatch funds: Under project H-375, **$89,730.00** and project H-380, **$67,585.00**. *FTE: For H-375, 0.7. and H-380, 0.5.*

D. Scope of Impact: State Specific PR.

IV. Key Theme - Tropical Agriculture (Irrigation)

A. Project H-387, *Microirrigation of Horticultural Crops in Humid Regions,* is an example of a research project addressing this key theme.

A field experiment was conducted at Juana Díaz Agricultural Experiment Station to evaluate irrigation scheduling on onion (Equanex variety) using Class A pan evaporation readings, crop factors of 0.65, 0.80, 0.95, 1.10 and 1.25 and leaf coverage factor of 0.75. The experiment was conducted in a soil of the series San Antón (Cumulic Haplustoll). A linear relationship between crop factor and yield was observed. Crop factor of 1.25 registered the higher onion yield (25,975 kg/ha) and the higher mean bulb weight (94.28 grams). This treatment registered the higher percentage of large size onion and the lower percentage of small size onion compared with the others crop factors used. Yield, post harvest evaluation and growth data is under statistical analysis.

B. Impact - Improved water and energy use efficiency in onion by adequate irrigation scheduling using Class A pan evaporation method.

C. Source of Federal Funds - Hatch funds: **$20,572.00**. *FTE: 1.3.*

D. Scope of Impact: State Specific PR

V. Key Theme - Tropical Agriculture (Fertilization)

A. Project CBAG 70, *Magnesium availability to banana and plantains in highly weathered soils,* is an example of research designed to tackle this key theme[2]**.**

[2] This is an example of a research project that may be viewed as addressing several key themes. It addresses fertilization in tropical agriculture, soil erosion (placed within goal 4) and socioeconomic concerns (goal 5).

A spilt plot experimental design with four replications was established on an ultisol (aquic haplohumult). Treatment categories and levels were the following: a) four target levels of soil Mg:K ratios: 8:1, 4:1, 1:1, and 1:4; b) two lime application treatments: no lime, limed to pH 5.5 c) two fertilization programs. Plant crop results pointed out to a strong correlation between soil exchangeable (Mge) Mg levels and the concentration of Mg in the leaves. A similar relation was observed between Mge and bunch weight, days to flowering, and number of leaves at flowering. The 0.30% Mg leaf values considered critical for adequate plant nutrition was obtained with approximately 2.5 cmol(+)/kg of magnesium. The results suggested that soil Mg content was the most relevant factor for Mg nutrition in plantains. However, results from our ratoon crop indicate that at marginal soil Mg levels (2 - 2.5 cmol(+)/kg) potassium antagonism can become critical. On our second year soil Mg/K ratios experienced a significant decrease due to an accumulation of potassium in the soil. This caused a reduction in the Mg content of the leaves at soil Mg contents similar to the first year.

B. Impact - Plantain and banana production plays an important socioeconomic role in numerous regions of the tropics. Magnesium (Mg) deficiency has been identified as a major yield constraint in those regions. The major soil factors causing Mg deficiency in highly weathered soils have been identified. This information will be used to formulate an Mg management program, which will be a significant contribution to the people of the tropical and subtropical regions of the U. S.

C. Source of Federal Funds - CBAG funds (98-34135-U6518): $21,407.21. *FTE: 0.63.*

D. Scope of Impact: State Specific (Puerto Rico and other tropical and subtropical regions of the United States).

Goal II. ***A safe and secure food and fiber system.***

Overview

Growing consumer awareness of the presence of pesticide residues in food has brought about more stringent legislation regarding pesticide use among agricultural producers, and closer surveillance of pesticide residues. National legislation mandated the reexamination and re-registration of thousands of pesticides products, updating health and environmental safety information. Puerto Rico's situation is complicated by the few pesticide uses that were registered for our crops. If these uses are eliminated in the re-registration process without other alternatives having been devised, our local agriculture will be greatly affected. Mounting health concerns and the re-registration process have increased the pressure on research and extension agencies to provide dependable data.

This is not a major area of work for AES. Among the few research projects currently running under this goal, two are good examples of how we tackle output indicators such as *Pesticides recommended for clearance* and outcome indicators such as *Market acceptability of certain agricultural products (either raw or processed) is increased:* Project H 372 (NRSP-4), *A National Agricultural Program to Clear Pest Control Agents for Minor Uses,* and Project CBAG 72, *Modified Atmosphere Packaging for a Tropical Fruit Mixture.*

Hatch funds under this goal: **$110,555.00** FTE: 1.7
CBAG: **$13,481.60** FTE: 0.0
SGF: **$3,771.00** FTE: 0.0

VI. Key Theme - Food Safety

A. Ten Magnitude of Residue and one Residue Decline GLP (Good Laboratory Practices) trials were established and/or completed for: fipronil/plantain/banana corm borer; imidacloprid/avocado/sucking insects; buprofezin/avocado/sucking insects; difenoconazole/yam/seed rot; and imidacloprid/banana/banana corm borer. Performance trials were coordinated and on various stages of completion for avocado (sucking insects); plantain and bananas (nematodes, banana corm borer). In a yam trial for the control of seed rot, seed pieces were treated with two fungicides, fludioxonil and difenoconazole: (1) post-harvest (for storage), (2) pre-plant and (3) both post-harvest and pre-plant. Best results were obtained when difenoconazole was applied post-harvest and pre-plant, resulting in 75% germination and 66% harvested plants. A highly significant difference in marketable tubers' yield (51.58 lbs., 280.88 cwt/A) was observed between this treatment and the untreated control (P = 0.05, LSD = 11.07). In two fungicide trials for the control of anthracnose in yam and "mal seco" in tanier, no significant differences between treatments (P = 0.05) were found with regard to percent disease and number and weight of marketable tubers.

B. Impact - There are very few, and in some cases, no alternatives for the control of pests and diseases in tropical crops. With the passing of the 1996 Food Quality Protection Act, some of those few uses are being limited or cancelled. Performance and magnitude of residue trials need to be carried out to register alternatives for pest control. The GPL trials on avocado will allow new registrations for insect control on various tropical crops, including avocado and mango. Through the banana work, registrations will be possible for both banana and plantain. The plantain trials will support the registration of a much needed alternative to control the banana corm borer. Results from the second year yam seed rot efficacy trial will support the registration of two alternatives for seed treatment.

C. Source of Federal Funds - Hatch funds (NRSP-4): **$71,810.00**. FTE: **1.1**.

D. Scope of Impact: State Specific PR

VII. Key Theme - Food Quality

A. A M.S. thesis, "Modified Atmosphere Packaging of Tropical Fruits", by Magaly Martínez-Ferrer was completed and defended successfully on May 18, 2000. A new M.S. student, Eduardo Padilla, started on the project July 1, 2000. A graduate school proposal to test different modified atmosphere on whole plantains is being written. The work will be conducted in conjunction with CATPI, an organization partially funded by the Commonwealth of Puerto Rico to help handicapped people get jobs. They are building a plant to package whole plantains for local distribution. Respiration test will be conducted to determine what type of packaging material to use. Then three different types of modified atmospheres will be tested for shelf-life.

B. Impact - The mango and pineapple project was presented to Campofresco, a large fruit juice distributor, so that implementation of the findings could be done commercially. The plantain findings will be used in the new plant being built, making exportation more feasible and decreasing the amount of local spoilage.

C. Source of Federal Funds CBAG Funds (98-34135-U6518): **$13,481.60**. FTE: Currently, one scientist, Dr. Carolyn Harper, is working with this project. She is ascribed to the Faculty of Agriculture, not to AES. Therefore, technically, the FTE would be zero.

D. Scope of Impact: State Specific (Puerto Rico and other tropical and subtropical regions of the United States).

Goal III. ***A healthy, well nourished population.***

AES did not intend to, and did not run projects under this goal.

Goal IV. *Greater harmony between agriculture and the environment.*

Overview

AES commodity of Natural Resources and Environment (NRE) has as its purpose not exclusively to further agricultural production and competitiveness, but to achieve that production while promoting a balance between agriculture and the environment. It is, therefore, concerned with both its research program and that of every other AES commodity.

Puerto Rico is rich in tropical natural resources and ecosystems. It has nine out of eleven soil orders present in the world. It has warm temperatures and abundant rainfall during most of the year, cooler subtropical temperatures at the higher elevations, and semiarid conditions on the South coast. Potential problems of underground water pollution are developing in our coastal valleys. In the central mountain range, intensive farming activities and the consequent destruction of primary and secondary forests have caused significant soil erosion and affected the quality and quantity of water supplies.

Various research projects try to address these problems, as will be discussed shortly. It should be no surprise that some of these projects closely intertwine NRE and agriculture. Through them, output indicators such as *Germplasm alternatives for erodible soils are recommended* and *New erosion control practices are developed,* and outcome indicators such as *Quality of agricultural and non-agricultural soils improves, Non-point pollution from agricultural sources decreases* and *Soil erosion decreases,* are addressed.

Hatch funds under this goal: **$214,249.00** FTE: 2.3
McIntire Stennis: **$92,397.00** FTE: 1.4

1 Key Theme - Agricultural Waste Management

1 *One project, currently closed, addressed this theme: CBAG 60,* Utilization of Sewage Sludge Compost as a Soil Amendment in the Tropics.

Field experiments were conducted on a mollisol and an ultisol of Puerto Rico. Treatments included a control (0 compost), 37, 74, and 148 t/ha/year of compost, as well as a single 444 t/ha application. Compost additions caused significant increases in pH, E.C., O.M, EDTA extractable metals (Zn, Cu, Fe, Cd, and Cr), and Olsen available P. Yield production (Cassava (Manihot esculenta, PI 12902)) was hindered by compost applications in each of the three years, mainly as a result of increases in soil salinity. The massive compost treatment (444 t/ha) still exhibited a significant effect on soil properties (Olsen P, O.M.) at the end of the experiment (after three years) which can be of great benefit to agriculture. Nutrient (i.e. N, and P) contributions from the compost became more significant with time denoting a residual effect. Nutrient distribution among the different cassava tissues were described by six broad categories, namely:
leaf >> peel >> pulp (nitrogen and calcium)
leaf > peel > pulp (phosphorus and magnesium)

peel >> leaf ≅ pulp (iron)
peel > leaf ≅pulp (potassium, sodium, copper (harvest))
leaf ≥peel >> pulp (zinc, copper (at early stage))
6) leaf > pulp ≥ peel (cadmium)

Cadmium was the only element whose concentration in the pulp tissue equaled or exceeded that of the p eel which points out the need to monitor the concentration of this element in soils where this crop is to be grown.

2 Impact - In Puerto Rico compost production was limited to meeting US standards for pathogens, and contaminants. Little consideration was given to factors that are relevant from an agronomic standpoint (i.e. O.M., nutrient content, salinity). By demonstrating the damaging consequences that a low quality product may have on agriculture this project has made an important contribution to the success of the composting industry in the island.

3 Source of Federal Funds - CBAG funds: This project closed.

4 Scope of Impact: State Specific PR

2 Key Theme - Soil Erosion

1 Projects MS-010, Germplasm alternatives for land reforestation on highly erodible soils of Puerto Rico, partly addresses this theme.

The adaptation and development potential of 10 trees, three shrubs, 27 grasses and 17 turf legumes is under evaluation at three highly eroded soil sites in Puerto Rico. Species development during the first establishing year was adequate for the Corozal site and intermediate and poor for the Vega Baja and Orocovis locations, respectively. Three species *Albicia procera* for Corozal and *Leucaena leucocophala* K 636 for the Vega Baja site grew well. Only at the Corozal site, grasses and turf legumes were significantly better at reducing soil erosion than wee trees and bare ground. Soil dissolved organic carbon estimation was significantly higher for ground cover species than for tree species and bare ground. Soil chemical composition of all eroded soil sites under consideration does not explain the changes in adaptation and development of the evaluated germplasm. For the Vega Baja and Orocovis sites, the use of fertilization amendments is highly recommended to improve germplasm response.

2 Impact - The selection of appropriate germplasm to reduce soil erosion and improve soil fertility will benefit many Puerto Rican areas with high erosion disturbances and problems.

3 Source of Federal Funds - McIntire Stennis funds: **$64,066.00**. FTE: 1.0.

4 Scope of Impact: State Specific PR

3 Key Theme - Nutrient Management

1 Project H-362, Mobility, transport and leaching of nitrate and phosphate in selected Puerto Rican soils, is dealing with aspects of this topic.

Six water wells located in farms on three municipalities on the south coast of the island were sampled each month. Water was tested for nitrate, ammonium, phosphate, Ca, Mg, K, pH and conductivity. Nitrate-nitrogen levels found in the six underground wells from January 2000 to December 2000 varied from 1 to 20 mg/L. Values higher than 10 mg/L NO_3-N were obtained from some samplings in five of the wells. These values exceed the maximum contaminant level (10 mg/L) set by USEPA for drinking water. These findings indicate that nitrogen is leaching to groundwater either from fertilizers or from other sources. We took soil samples from two irrigation experiments at Lajas and Juana Díaz substations to study nitrate movement through the soil profile and to determine whether leaching losses were occurring. Irrigation was applied at rates of 25, 50,75 and 100% of the amount lost the week before by evaporation. Analyses are still pending.

2 Impact - Our findings for the last 3.5 years indicate that nitrate is leaching and affecting groundwater quality. Nitrogen fertilizer, applied at high rates in the agricultural activities in the area, is a possible source of contamination. Research must continue in order to recognize patterns of variation in NO_3-N level and correlate them to precipitation and agricultural activities.

3 Source of Federal Funds - Hatch funds: **$159,278.00.** FTE: 1.7.

4 Scope of Impact: State Specific PR

Goal V. *Enhanced economic opportunity and quality of life for Americans.*

Overview

The rapid economic and social transformation undergone by Puerto Rico from 1940 until the early 70's –from an agricultural to an industrial-based society—brought about improved standards of living in terms of life expectancy, education and housing, but insufficient progress in terms of reducing the prevailing unemployment rates and chronic poverty of the majority of the population. Changes in the global economy since the mid-seventies, with the concomitant restructuring of major local economic sectors—agriculture, manufacturing, government and service, among others—have exacerbated these adverse conditions, particularly in rural areas. Whereas the contribution of agriculture to the Gross Domestic Product has diminished in recent years, the continued viability of farming is critical for maintaining and improving the quality of life in Puerto Rico, because of its high multiplier effect and the lack of other alternative employment opportunities in rural areas.

The economic well-being of individuals, families and communities is an important component of what has been conceptualized as "quality of life". Our program is directed toward providing the socioeconomic research required to formulate alternatives that can potentially enhance the economic well-being and the quality of life in rural areas.

The following two projects are examples of how AES tackles some of the output and outcome indicators that we introduced in the Five Year Plan of Work, such as (output indicators) *Effects of changes in the international and local market conditions for the Island's products with respect to the economic situation of producers, particularly of starchy and vegetable crops, are documented*; *Local dimension of community food systems are assessed*; *New marketing and distribution alternatives for regional production are recommended*; *Cost effective and environmentally sound techniques for processing agricultural products, coffee in particular, are developed*; *Agriculture's contribution to local employment opportunities in the targeted region are evaluated* and (outcome indicators) *Percent of farm operator's income derived from agriculture increases*; *Employment opportunities in the locality increase*; *The agricultural gross income of the targeted region increases*; *The number of farms and the amount of land in farms is maintained or increased.*

Hatch funds under this goal: **$66,603.00** FTE: 1.4

4 Key Theme - Other (Rural Reestructuring and Globalizing Environment)

1 Projects H-386 and H-388 cover these topics.

A list of key informants for the proposed case study on technological change in farinaceous crops was compiled during this year and a preliminary interview guide was prepared. Based on the results from this project's analyses of historical trends in the production and trade of farinaceous crops, and of former project H-364 study of farming in the central region of Puerto Rico, a book chapter draft for the edited book *Communities of Work: Rural Restructuring in Local and Global Context* (Ohio University Press) was written. The chapter, entitled "Livelihood Strategies of Farmers in Puerto Rico's Central Region: Survival in the context of Economic Restructuring and Policy Change" argues that policies (agricultural and otherwise) have had a differential impact upon rural/agricultural classes, and the strategies different types of farming households adopt to negotiate change depend on their socioeconomic characteristics, on the resources commanded by the farming operation, and on the institutional arrangements developed historically in the different regions of the island. These arrangements are a reflection of historical politico-economic struggles and decisions, which still impinge on the future of rural areas, and largely determine who benefits, losses, or survive the current instability of global and local economies. The authors suggest that the implementation of regional policies sensitive to the resource endowment and peculiarities of disadvantaged localities such as the central region of Puerto Rico, should be devised to palliate the effects of continued marginalization of small farmers, agricultural decline and rural poverty.

2 Impact - The databases established under this project, the documentation of technical change in farinaceous crops, and the analyses of the consequences of agricultural restructuring in the central region, are all important sources of information for the design of policies specifically targeted towards improving the conditions of farmers in the central region—the rural stronghold of Puerto Rico.

3 Source of Federal Funds - Hatch funds: Under project H-386, **$9,645.00** and project H-388, **$14,679.00**. FTE: For H-386, 0.3. For H-388, 0.4.

4 Scope of Impact: Puerto Rico

Stakeholder Input Process:

As explained in the five year POW, our research program is divided in eleven commodities[3]**, and all of our research projects are ascribed to one commodity. During a commodity meeting, active projects are discussed and evaluated.**

The commodities met this year, as every year, and the input of the participants was requested (previous to the meeting), received, collected, analyzed and summarized. It is the responsibility of the Commodity leader to do this. He/she contacted the farmers, scientists, government officials, individuals and public at large, and other parties who may have been interested in the particular commodity and who provided the input necessary to point the direction which the commodity will follow. To encourage stakeholder participation, the leader may have contacted them personally, through letters of invitation, or through the local Agricultural Agents. It is possible that a commodity will meet more than once a year, when necessary[4].

The identification of the stakeholders is a rather simple process: the first to be contacted are the farmers, scientists, government officials and private individuals and/or groups who work mostly or exclusively with the particular commodity. The meetings are open to anybody who may be interested.

AES has a Strategic Plan that is updated annually, using this input. Research projects may lose or acquire priority, and new projects may be created (depending on available personnel and fiscal resources). The Plan is divided up by commodities, which in turn are divided by crops (except, or course, dairy, beef and environment and natural resources), which are then divided by problem, need or situation. Proposed strategies are listed.

Program Review Process:

[3] **Dairy, coffee, plantains and bananas, vegetable crops, fruit crops, ornamentals, beef, root and tuber crops, basic grains, environment and natural resources, and sugarcane.**

[4] **For example, Coffee met this year for a second time to receive the report of a special committee it had created, regarding the situation of the coffee industry (including agricultural production, processing, distribution, and other related topics).**

There have been no significant changes in our Program Review Processes since our Five Year Plan of Work was submitted.

Evaluation of the Success of Multi and Joint Activities:

Did the planned programs address the critical issues of strategic importance, including those identified by the stakeholders?

Agricultural production is the long term critical issue of the projects ascribed to the first goal (which encompasses most of our research projects), and it is certainly addressed by the planned program. As stated in the five year POW, each research project has its specific short and intermediate term critical issue (s), which were reviewed in the commodity meetings. In fact, that is the purpose of a commodity meeting, along with the gathering of input. Through these revisions, the long term critical issue was also reviewed.

The changing consumption habits of Puerto Ricans, the market participation of local producers, and the growing consumer awareness (pesticide residues; health and environmental safety; alternate pest control; and availability, post harvest storage and processing) are the long-term critical issues of the projects ascribed to the second goal. Water pollution control, integrated pest management, and sustainable agriculture are the long-term critical issues of the projects ascribed to the fourth goal. Quality of life is the long-term critical issue of the projects ascribed to the fifth goal.[5] **As in the case of the first goal, these long-term critical issues were addresses by the planned programs, and were indirectly reviewed when the short and intermediate term critical issues of each research project were reviewed.**

[5] **AES carries no research project ascribed to the third goal.**

Did the planned programs address the needs of under served and under represented populations of the state?

Puerto Ricans are a large majority within the Commonwealth of Puerto Rico, but we are a minority within the larger context of American citizenry. We tend to see ourselves as one single group, not divided by ethnicity or cultural preferences, even though we are a multiracial people.

Women and handicapped individuals are encouraged to participate in the annual commodity meetings, just as anybody else. There are some female farmers[6], but most are male. Currently, we have no handicapped farmers in our lists. As for other stakeholders, women are more fairly represented among scientists, government officials, private individuals, or representatives of private groups. Handicapped individuals are less so.

Did the planned programs describe the expected outcomes and impacts?

Yes. Indicators were created and submitted for each of the five goals, in the five year POW, with the purpose of describing this. It should be kept in mind, however, that this is a long term, ongoing process, and twelve months may not be enough to effect noticeable changes.

Did the planned programs result in improved program effectiveness and/or efficiency?

Yes. Planning is always an invaluable tool to improve effectiveness and efficiency.

[6] It may be noted that in 1994, a female farmer, Mrs. Blanca Lebrón, a vegetable grower from the South Coast of Puerto Rico, was chosen Farmer of the Year by the Puerto Rico Department of Agriculture.

APPENDIX

Examples of Seminars offered at AES
1 October 1999 – 30 September 2000

Alternatives to insect pests in the Caribbean. April 12, 2000.

Graft transmissible diseases in Citrus. Certification of vegetable material free of graft transmissible diseases in Citrus. October 24, 2000.

Compost preparation and Natural home gardens. December 12, 2000.

Food preservation. December 12, 2000.

Medicinal plants and tropical spices. December 13, 2000

Grafts in fruit crops. December 13, 2000.

Structures for hydroponic cultivation. December 14, 2000.

Pest management and use. December 14, 2000.

The phylogeny of Whitefly Transmitted Viruses in the Caribbean Basin. October 3, 2000.

Techniques for Identification of Semiochemicals from Natural Sources. October 25, 2001.