PROPOSAL FOR THE ESTABLISHMENT OF A DOCTORAL PROGRAM IN TROPICAL AGRICULTURE AT THE UNIVERSITY OF PUERTO RICO

College of Agricultural Sciences
University of Puerto Rico at Mayagüez

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1. INTRODUCTION

1.1. Title of the program and degree to be conferred

The title of the proposed program is the Doctoral Program in Tropical Agriculture (CIP Code 01.0000; Agriculture, General). The degree to be conferred will be a Doctor of Philosophy (Ph.D.) in Tropical Agriculture.

1.2. Brief description of the program

Agricultural Sciences involve the planning, development and analysis of agricultural production techniques within the context of an appropriate use of natural resources. Because of the great diversity in topics related to agriculture, different areas of specialization focus on one or several disciplines. Professionals in agricultural sciences and natural resources, however, often need to integrate information from different disciplines. The proposed academic program has a multidisciplinary scope for the teaching of agricultural sciences and natural resources in the tropics.

After completing residency, the graduate student must pass a qualifying exam and develop a dissertation topic that demonstrates a thorough understanding of his/her area of expertise and creativity. The dissertation research should represent an original contribution to science or technology in the area of agricultural sciences or natural resources in tropical environments.

1.3. Non-conventional modalities

Some of the courses from the Department of Agricultural Economics will be available online, including: ECAG 6601, ECAG 6604, ECAG 6611, ECAG 6631, ECAG 6635, ECAG 6641, ECAG 6650, ECAG 6654, ECAG 6660, ECAG 6665, ECAG 6666. These courses could be part of the curricular sequence of the Doctoral Program.

1.4. Date when the program is expected to be offered

The Doctoral Program in Tropical Agriculture will begin on August 2020.

1.5. Duration of the program

In accordance with the norms of graduate studies of the University of Puerto Rico Mayagüez Campus, full-time doctoral students who enter the program with a master's degree should complete the requirements for a Ph.D. degree within 3-4 years, and doctoral students who enter the program with a bachelor's degree should complete the requirements for a Ph.D. degree within 6-8 years.

2. JUSTIFICATION FOR THE PROGRAM

2.1. Academic reasons for the establishment of the Program

The development of graduate programs and the associated research is one of the primary priorities of the UPR Mayagüez Campus. In that context, support of scientific research is highly important to be able to offer an education of excellence. One of the basic functions of the College of Agricultural Sciences is research and the proposed doctoral program will strengthen this area with the research that students of the doctoral program will develop: likewise, the research program of the College of Agricultural Sciences will enrich the research formation of the students in the program.

The program is designed to promote and strengthen scientific research oriented toward the advancement of knowledge and efficient and sustainable use and conservation of natural resources in the tropics. This research would help solve problems affecting the agricultural sector of Puerto Rico, the Caribbean and other parts of the world.

The demand for the doctoral program is supported by the large number of students graduating from the different Masters in Science programs administered by the departments of the College of Agricultural Sciences. Many of these students are qualified to continue doctoral studies, and most have expressed an interest in continuing

postgraduate studies. Moreover, prospective students from several different Latin American countries have expressed an interest in a program of this nature. It is hoped that the demand will increase after the program is aggressively promoted among professionals in Puerto Rico and other countries. Special attention will be given to promote the program in Central America, the Caribbean, and the United States.

A competitive advantage of the doctoral program for foreign graduate students is the relative low cost of higher education in Puerto Rico, compared with that of similar programs in the United States. This fact should prove to be particularly attractive to international agencies that provide economic assistance for doctoral studies. At present, agreements exist among universities in the Caribbean Basin, such as UNICA, and bilateral agreements between the University of Puerto Rico Mayagüez Campus and other universities in the Caribbean, South and Central America. These agreements are designed to provide graduate training in the College of Agricultural Sciences for professors from Latin America.

Puerto Rico, the Caribbean, Central America and many countries in South America need to maintain and, in some areas, increase agricultural production and at the same time conserve the scarce agricultural resources that are available. A common denominator among all countries in the region is a lack of advanced research needed to develop scientific alternatives for agricultural development. In addition, the absence of a doctoral program obliges our graduates to continue their studies abroad or to pursue degrees in other disciplines.

Tables 2.1 and 2.2 summarize information concerning the number of doctorate degrees in agricultural sciences conferred in the United States and Puerto Rico during 2016. It should be noted that the number of Hispanics who received doctorate degrees is only 4.49%. When we consider the number of doctorates degrees conferred to Hispanics in the areas proposed for the Doctoral Program in Tropical Agriculture this figure is only 1.2% (17/1,385).

Table 2. 1. Doctorates in agricultural sciences by subfield and gender. (Extract From: National Science Foundation. Science and Engineering Doctorates 2018. Doctorate Recipients from United States Universities. http://www.nsf.gov/statistics/sed/2018/data_table.cfm).

Subfield of study	Total	Male	Female	% female
Agricultural sciences, natural resources	1,385	760	624	45.1
Agricultural economics	113	73	40	35.4
Agronomy, horticulture science, plant breeding, plant pathology, plant sciences-other	303	180	123	40.6
Animal nutrition, poultry science	63	40	23	36.5
Animal science, other	83	38	45	54.2
Environmental science	1 93	88	105	54.4
Fishing and fisheries sciences/management	47	26	21	44.7
Food science, food technology-other	163	75	88	54.0
Forest biology, forest management, wood science, forestry sciences-other	87	62	25	28.7
Natural resources/conservation	68	36	32	47.1
Soil chemistry, soil sciences-other	61	27	34	55.7
Wildlife/range management	86	46	40	46.5
Agriculture-general, agricultural science-other	118	70	48	40.7

Table 2. 2. Doctorates in Agricultural Sciences classified by subfield and ethnic group, year 2018. (EXTRACT FROM: National Science Foundation, Science and Engineering Statistics 2018, *Doctorate Recipients from United States Universities* http://www.nsf.gov/statistics/sed/2018/data_table.cfm)

Subfield of study	All doctorate recipients	Temporary visa holders	U.S. citizens and permanent residents							
			Total	American Indian or Alaska Native	Asian	Black	Hispanic	White	Two or more races	Other or unknown race
Agricultural sciences, natural resources	1,385	516	758	4	29	44	52	582	10	4
Agricultural economics	108	56	43	0	3	8	6	22	0	2
Agronomy, horticulture science, plant breeding, plant pathology, plant sciences-other	347	125	153	0	7	3	12	126	2	0
Animal breeding, animal nutrition, poultry science	85	28	55	1	0	2	3	48	1	1
Animal science, other	86	32	46	0	2	2	1	39	0	1
Environmental science	206	65	126	2	3	11	10	94	2	0
Fishing and fisheries sciences/management	53	10	43	1	0	1	0	41	0	0
Food science, food technology-other	153	91	56	0	5	9	3	38	1	0
Forest biology, forest management, wood science, forestry sciences-other	97	31	54	0	2	2	2	47	1	0
Natural resources/conservation	92	20	64	0	3	2	4	53	1	0
Soil chemistry, soil sciences-other	66	30	35	0	2	2	3	26	2	0
Wildlife/range management	41	7	34	0	0	0	3	29	0	0
Agriculture-general, agricultural science-other	51	21	29	0	2	2	5	19	0	0

2.2. Justification for the new program to the Puerto Rican and Caribbean community

The new doctoral program in Tropical Agriculture will contribute to meet of pressing needs related to (1) planning, critical analysis, and the appropriate use of natural resources, and to (2) the sustainable and profitable management of agricultural land. Institutional commitments of the College of Agricultural Sciences include the water, quality improvement, protection of the productivity of our fragile soils, maintenance of the ability of our agricultural enterprises to compete in a global economy, provision of appropriate practices for agricultural waste management and the protection of our agriculture from losses by diseases and pests. Given the great diversity and the complexity of the aforementioned problems, professionals with advanced knowledge are needed to identify the causes of these problems and to develop solutions for confronting the challenges that our agriculture faces.

For decades, the proposed solutions to problems of agriculture in Puerto Rico have depended, in large part, on science developed in other cultural and environmental contexts and more appropriate for agricultural systems that achieve efficiency through intensive input. The proposed doctoral program will lead to more sophisticated scientific and technological research and will place the College of Agricultural Sciences of Mayaguez campus in a stronger position to compete for research funds. The multidisciplinary nature of the program will permit a more holistic approach and the development of ampler sustainable agricultural practices.

Law 45 of the Commonwealth of Puerto Rico entitled “Law of the Teaching Career”, which was designed to improve the quality of teaching, promotes the academic preparation of teachers in Puerto Rico by providing incentives for public school teachers to pursue postgraduate degrees (masters and doctoral). The proposed doctoral program will permit teachers in Agricultural Education and Extension to achieve these objectives.

At present, local governmental agencies and private companies frequently import consultants for short-term assignments. In addition, to obtain this type of talent Puerto

Rico depends on graduates from doctoral programs from the exterior. Finally, experience suggests that generally the most appropriate solutions to problems are found when the solutions are developed in the ecological and socioeconomic contexts where the problems exist. Therefore, it is essential that research and doctoral training be conducted in Puerto Rico to develop the most appropriate solutions for Puerto Rican agriculture.

The new doctoral program in Tropical Agriculture should also help solve problems in neighboring countries that have a similar culture, climate and agriculture. Puerto Rico can serve as a cultural link between North and South America. Puerto Rico's spanish language and Iberian-Antillean culture welcome science education with open arms that symbolically encompass the western hemisphere. For that reason, the proposed program will offer a doctoral degree program designed mostly along the style of a U.S. university but with adjustments made to provide instruction in the language and cultural environment of fellow Latin America and Caribbean students. In the Caribbean, most of Latin America, and United States lack an adequate number of doctoral programs in tropical agriculture. Therefore, the proposed program will make the College of Agricultural Sciences an important center in the western hemisphere for education in tropical agriculture and natural resource management.

2.3. Employment opportunities for graduates of the program

The proposed program is designed to produce professionals who are capable of effectively contributing to the development of the infrastructure and the agricultural policies of Puerto Rico, agricultural research, and higher education. In addition, one of the principal goals of the program is to produce and retain a critical mass of professionals capable of providing leadership in the identification of the future direction of our agricultural development, and capable of ensuring the protection of our natural resources. In addition, the continued creation of new B.S. degree programs in agriculture, natural resources and related areas in different public and private universities in Puerto Rico should create employment opportunities for graduates of the proposed doctoral program and help to insure academic excellence in these new B.S. degree programs. The Appendix A show

examples of advertisements of employment opportunities that require a Ph.D. in the areas of the proposed Program.

The following public agencies and private companies are potential employers for the type of professional the proposed doctoral program will produce:

- Agencies of the Commonwealth of Puerto Rico
  - Planning Board
  - Department of Agriculture
  - Environmental Quality Board
  - Department of Natural and Environmental Resources
  - Development Bank
  - Department of Education
- Universities
  - University of Puerto Rico
  - Inter-American University
  - Ana G. Méndez University System
  - Catholic University of Puerto Rico
  - University of Sacred Heart
  - Universities in other Latin American countries and in the Caribbean and the U.S.
- Private Companies
  - AgReliant Genetics
  - BASF
  - Bayer CropScience
  - Corteva Agriscience - DowDupont
  - Illinois Crop Improvement
  - RiceTec
  - Pharmacia Chemonics
  - RONCO
  - PanAmerican Fertilizer
  - Maartex
  - Syngenta
- International Agencies
  - World Bank
  - Inter-American Development Bank
  - Food and Agriculture Organization (FAO)
- Non-governmental organizations (NGOs)
  - WWF
  - Forests for the Future
  - Greenpeace
  - Conservation Trust
  - Oxfam
  - CARE

- Federal Agencies
    - United States Department of Agriculture (USDA)
        - Animal & Plant Health Inspection Service (APHIS)
        - Agricultural Research Service (ARS)
        - Foreign Agricultural Service (FAS)
        - U.S. Forest Service
        - National Agricultural Statistical Service (NASS)
        - National Resource Conservation Service (NRCS)
        - Agricultural Marketing Services (AMS)
        - Food Safety and Inspection Service (FSIS)
        - National Institute of Food and Agriculture (NIFA)
    - Department of the Interior
        - Fish & Wildlife Service
        - U.S. Geological Survey (USGS)
        - Bureau of Land Reclamation
        - National Park Service
    - Environmental Protection Agency (EPA)
    - Department of State
        - U.S. Agency for International Development
        - Bureau for Oceans, International Affairs and Environment
    - Department of Defense
        - National Aeronautics and Space Administration (NASA)
    - Department of Health
        - Food and Drug Administration (FDA)

3. RELATION OF THE PROGRAM TO THE GLOBAL STRATEGIC PLAN OF THE UNIVERSITY OF PUERTO RICO

The primary mission of the University of Puerto Rico is to increase knowledge through the arts and sciences, and to contribute to the development, culture, and enjoyment of the ethical and aesthetic values of the society (http://www.upr.edu/mision-y-vision-upr). The 2017-2022 Global Strategic Plan of the University of Puerto Rico has the explicit goal of enriching the academic offering of the University with programs that are pertinent, different, competitive, that respond to the evolution and requirements of the disciplines, the professional market and the professions, thus promoting the development of responsible and productive citizens well prepared to exercise their academic disciplines in Puerto Rico and elsewhere (http://www.juntagobierno.upr.edu/plan-estrategico-upr-2017-2022).

The College of Agricultural Sciences (CAS) is part of the Mayagüez Campus of the UPR, one of its original units over 100 years ago, and the only unit in the UPR system that currently offers post-graduate degrees in agricultural and food sciences. The CAS mission is to train new professionals (through formal education), to develop new knowledge and technology (through research) and to disseminate knowledge to new and existing stakeholders (through extension) to enhance economically viable and sustainable agricultural production, and to promote food security and societal wellbeing in Puerto Rico and internationally (https://www.uprm.edu/ciag). The Ph.D. Program presented in this proposal is in agreement with the Global Strategic Plan of the University of Puerto Rico, particularly with the following Critical Topics:

3.1. Critical Topic 6: Strive for the Continued Updating of Academic Programs

Among the strategic directions of this Critical Topic, the following are closely related to the proposed program:

- Develop structures and administrative procedures that favor multidisciplinary academic programs.

The multidisciplinary nature of the proposed doctoral program, which is in agreement with the aforementioned strategic direction, is achieved through collaboration among different departments in the College of Agricultural Sciences and with other departments on the University of Puerto Rico Mayagüez Campus.

3.2. Critical Topic 8: Increase Creative Activity and Research

The development of scientific research is of basic importance to the proposed program. The objectives of the proposed program dealing with scientific research support the following Strategic Directions of Critical Topic 8:

- Provide the conditions and institutional environment needed to promote research and creative activities by strengthening the following entities:
    - Administrative and management support
    - Physical installations

- Equipment and materials
- Financing
- Developing academic tasks
- Facilitating accessibility of our researchers to peers in other institutions and countries.

• Stimulate the application of new knowledge generated from research and creative activity toward the development of Puerto Rico and the introduction of new sciences.

• Establish collaborative activities with other universities, private industry, commerce and government in and outside of Puerto Rico.

• Stimulate research activities in the practice of all of the professions.

• Search for additional sources of external funding.

3.3. Critical Topic 9: Strengthen Graduate Programs

The program is innovative since no other university in Puerto Rico or the Caribbean offers a program similar to the one been proposed. This multidisciplinary program has great potential for collaboration among campuses within and outside of Puerto Rico. This program definitely strengthens graduate programs and is consistent with all of the Strategic Directions of this Critical Topic, which are:

• Strengthen research in the academic programs offered.

• Develop innovative programs attuned to the needs of society and the generation of knowledge.

• Promote and facilitate inter- and intra-disciplinary research within the UPR and with other universities within and outside of Puerto Rico.

3.4. Critical Topic 11. Emphasize and Promote the Presence, Participation and Contribution of the University to Social Progress Within and Outside of Puerto Rico.

All of the strategic directions in this Critical Topic 11 are closely related to the objectives of the proposed program:

• Identify specific areas of need in communities and promote efforts in the university to search for possible solutions to the problems.

- Inform the society of the contributions of each sector and unit of the University.
- Promote an image of excellence in all tasks of the University of Puerto Rico, an image that reflects the commitment of all members of the institution.
- Promote research and collaborative consulting on topics dealing with quality of life, education, health, public security, the environment, public service and the economic development of a more internationally competitive Puerto Rico.

4. RELATION OF THE PROGRAM TO OTHERS THAT ARE OFFERED

4.1. In the same institutional unit

The proposed doctoral degree program will allow the College of Agricultural Sciences to broaden the offerings of graduate programs in tropical agriculture and natural resource management. This proposed doctoral program is directly related to the M.S. degree programs presently offered in the Faculty of Agricultural Sciences (Agronomy, Soils Science, Horticulture, Animal Science, Crop Protection, Food Science and Technology, Agricultural Economics, Agricultural Education and Extension, and Agricultural Education and Extension). Qualified graduates from these programs will be considered for admission to the doctoral program in their respective fields. Moreover, many of the courses offered for M.S. degrees can be used to earn credits for the doctoral program.

To explore the extent of interest in the proposed Ph.D. Program, Dr. Morales Payan, Director of International Programs of the College of Agricultural Sciences, conducted a survey online in October 2018. The survey was sent to all the students currently enrolled in MS programs at the Mayagüez Campus. The background information provided about the program included the areas of interest, the number of credits needed in courses and research, and the length of time expected for completion. Within one week, there were responses from 44 students. Only 5 students indicated they were not interested: One of them saying he/she needed more details about the program to express interest, another one was interested in a different area for a Ph.D. (economics), another one preferred to study in an English speaking country so he/she could master the language, and another one indicated he/she was already accepted in a doctoral program elsewhere. The other 39

students expressed interest in becoming doctoral students, if the program started accepting students approximately within one year, and mentioning reasons such as language, cost, staying in the island with the family, opportunity to do research in tropical species that are understudied and are useful to Puerto Rico, opportunity to continue their studies with faculty they know and value, and their high regards for the education they are already receiving in the Mayagüez Campus. The results of this survey are encouraging in terms of the potential pool of applicants for the Ph.D. Program in Tropical Agriculture considering only the graduate students already in campus. Moreover, that survey did not include students in related MS programs at the Mayagüez Campus, such as Biology, that may well be considered for the Ph.D. in Tropical Agriculture.

In Table 4.1 shows the number of degrees granted by the Faculty of Agricultural Sciences during the last five years. Approximately, 20% of the graduates from the M.S. programs in agricultural sciences of the Mayagüez Campus continue doctoral studies abroad.

Table 4. 1. Degrees granted by the Faculty of Agricultural Sciences, 2014-2019.

Academic Program		2014-15	2015-16	2016-17	2017-18	2018-19
Baccalaureate	General Program in Agricultural Sciences	19	18	15	14	15
	Agronomy	22	25	22	21	22
	Agricultural Economics	2	0	2	8	4
	Agricultural Education and Extension	5	8	10	4	9
	Agricultural Extension	1	1	10	4	5
	Horticulture	14	6	13	22	13
	Animal Science	53	56	56	77	97
	Agricultural and Environmental Systems	9	21	20	15	21
	Crop Protection	4	4	10	2	4
	Agribusiness	1	2	7	6	5
	Soils	3	3	2	3	1
	Total	**133**	**144**	**167**	**176**	**196**
Masters	Agricultural Economics	0	1	1	2	5
	Agricultural Education and Extension	0	1	1	1	0
	Agricultural Extension	0	1	0	1	0
	Horticulture	2	2	4	3	1
	Animal Science	10	11	8	4	8
	Agronomy	2	4	6	5	3
	Soils	1	3	3	1	6
	Crop Protection	4	9	11	2	8
	Food Science and Technology	8	6	11	7	8
	Total	**44**	**40**	**39**	**26**	**39**

Graduates from other programs in the Faculty of Agricultural Sciences and other programs at the University of Puerto Rico Mayagüez Campus, such as biology, chemistry, marine sciences and the environmental option of civil engineering, could be considered for admission to the doctoral program. In some cases, students could be admitted with a requirement to correct any deficiencies.

4.2. At other units in the University of Puerto Rico

The proposed doctoral program does not exist in other campuses of the University of Puerto Rico. Graduates from the M.S. degree programs in applied sciences from the Río Piedras and the Medical Sciences campuses could be considered for admission to the doctoral program in Tropical Agriculture. Graduates from B.S. degree programs from other campuses of the UPR System would have the opportunity to continue studies in the Faculty of Agricultural Sciences. For example, it is already common that biologists (B.S.) graduated from other UPR campuses apply and are accepted to the MS programs in the Crop Protection, Soils, Agronomy, and Horticulture. Between 2012 and 2017, every academic year, on average of 6 biologists and other non-agronomists were accepted to MS programs in the Agricultural Sciences Department (nearly 20% of all newly accepted students to the MS programs). Similarly, it is conceivable that BS graduates in majors other than agriculture would consider applying for admission in the proposed doctoral program, either directly from the BS or after completing the MS requirements in one of the existing programs in the Mayagüez Campus, elsewhere in Puerto Rico, or abroad.

4.3. At other universities in Puerto Rico

Graduates from M.S. degree programs in science at the Inter American University and Ana G. Mendez and other programs in Puerto Rico could be considered for admission to the doctoral program. In some cases, students could be admitted with a requirement to correct deficiencies. The Faculty of Agricultural Sciences will develop collaborative projects with other universities that have study programs or research related to agriculture. Traditionally, several MS programs in the Agricultural Sciences Department of the Mayagüez Campus have been accepting students that hold BS degrees (mainly in Biology) from other universities in Puerto Rico. In the years 2012-2017, those MS programs accepted on average 6 new students that held Biology degrees from other universities in Puerto Rico.

4.4. Potential applicants from abroad.

An online survey, similar to the one described above, was conducted by the Office of International Programs of Agricultural Sciences (Mayagüez Campus) in October and November 2018. The only differences were (1) it was sent to agencies and universities abroad, and (2) they were asked to say what was their country of origin. There were 47 people responding, of which only 2 said they would not apply to the Ph.D. Program in Tropical Agriculture in the Mayagüez Campus. The reasons given were (1) the person considered himself/herself to be too old to go back to school, and (2) another respondent indicated he/she felt his/her profession (geographer) may not fit well in the doctoral program. The other 45 people responding to the survey stated that they were interested and would consider applying; among the reasons presented were (1) the reputation of the CAS and the UPR, (2) the location (Caribbean, tropical, nearby or similar to their country of origin), (3) most courses being taught in Spanish, (4) they had graduated from the Mayagüez Campus or other units in the UPR system, (5) high regard for the faculty, (6) potential of lower cost of living and studying in Puerto Rico as opposed to other places, and (7) available areas of studies.

The people that responded positively from abroad were from the Dominican Republic (33), Ecuador (6), Haiti (2), El Salvador (2), Bolivia (1), Uruguay (1), Panama (1), and Guatemala (1). These countries are also represented by students in the MS programs already offered in Agricultural Sciences in the Mayagüez Campus.

The results of this survey among potential international students is also encouraging, showing that a large number of applicants may be expected from abroad as well as from local students.

5. DESCRIPTION OF THE PROGRAM

5.1. Philosophy, mission, goals, and specific objectives of the program

Scientific and technological advances in the last decades have placed professionals in agricultural sciences in a key position in modern society. The fragility of ecosystems, the need to produce more food and fiber, and the new structure of world markets make the strategic and sustainable use of agricultural and natural resources a necessity. Recent changes in our society have forced professionals in agriculture to become not only highly

skilled technicians but also managers of highly complex scientific, economic and social projects. Moreover, the globalization of markets and the increased competition among agriculture, industry and society for natural resources require more than ever that professionals in agriculture have a holistic and multidisciplinary vision.

The proposed doctoral program in Tropical Agriculture pursues the forging of intellectuals who are dedicated to the continued search for solutions, that utilize the most recent advances in science, and who are capable of adjusting to the changing conditions that are expected in as the 21st century unfolds. Therefore, **the basic philosophy** of the program is to develop the cognitive skills necessary to make significant contributions to the agricultural sciences that will lead to benefits for the agricultural sector, the government, and society. Graduates of this Program are expected to also possess skills in different forms of communication, be able to work individually as well as in collaborations with their peers and other co-workers, have a sense of ethics, and to envision practical applications for their discoveries.

The doctoral program in Tropical Agriculture proposed here will be housed in the CAS. So far, the CAS has been successful in developing professionals in tropical agriculture at the BS and MS levels. However, to prepare their personnel at the Ph.D. level in agriculture and food sciences, Puerto Rico and most of Latin America have had to send their students to be trained in universities in the USA, Europe and leading countries in Oceania and Asia, at great expense and often in unfamiliar environments and with problems alien to those of their native lands.

The mission of the Doctoral Program in Tropical Agriculture is to prepare in Puerto Rico, through rigorous scientific and academic training, human resources (new doctors of philosophy in agricultural sciences) who are competent researchers, innovators and leaders, capable of generating new knowledge to expand the frontiers of science and to solve problems and overcome limitations in agricultural systems, with emphasis in tropical environments, useful to Puerto Rico and other places with similar conditions and language. This Doctoral Program is aimed at fulfilling the need of educating professionals at the highest academic level directly in the tropical region, a geographical area with its special circumstance, challenges and opportunities, with a strong need for human resources able to create and use scientific knowledge for sustainable growth and development of its

natural resources and food security, by working in governmental and non-governmental agencies, various industry, and academia, becoming a force change.

The Program Goals are to academically prepare new cohorts of highly skilled and ethical professionals at the doctoral level, trained to excel mainly, but not exclusively, in their work in tropical conditions, experts and leaders in their fields, capable of solving existing problems and generating new information and technology to expand basic and applicable knowledge related to agriculture, natural resources, and food science and technology. These new generations of thinkers, problem-solvers and innovators in the agricultural sciences should have a tremendous impact in the body of practical and basic knowledge as well as in the advancement of solutions for critical issues in food production and conservation of natural resources to sustain growing populations, situations that plague both in Puerto Rico and the rest of the planet.

The Program is aimed at being international in scope from its beginning, as Puerto Rico has a unique geographical location in the middle of the Caribbean Sea and between North America and South America, with language, climate and agricultural problems in common with many countries in the tropical and subtropical Americas, whose populations may feel more comfortable pursuing Ph.D. studies in Puerto Rico rather than in more northern latitudes. The CAS has a superb reputation abroad, and the faculty contributing to this Ph.D. Program aspires to have it become one of the top doctoral programs in tropical agricultural sciences in the world. Therefore, **a goal of this program** is to expand the internationalization of the CAS and the Mayagüez Campus in particular and the UPR System in general. As a consequence, our University will be become one of the finest destinations for international students interested in tropical agriculture, increasing the opportunities for interaction, exchange and mutual enrichment of our society with other cultures, universities and agencies abroad.

The objectives of this Program are:

1. To increase the offer of graduate studies in general, and doctoral studies in particular, in the University of Puerto Rico System. Moreover, it will be the first and only doctoral program in agricultural sciences in Puerto Rico.
2. To establish a doctoral program in agricultural sciences in a Spanish-speaking location within the US educational system, an appealing prospect for international students from Latin America.
3. To promote multidisciplinary academic research. To train students to apply the scientific method to solve problems and develop new knowledge in tropical agriculture.
4. To expose students to new knowledge and techniques in agricultural sciences, with emphasis in tropical species and environments.
5. To educate students to be critical thinkers and innovators in regards to tropical agriculture systems and problems.
6. To train students in skills that allow them to work individually as well as in collaboration, as necessary.
7. To strengthen in students a culture of professional ethics.
8. To instill in students a culture and consciousness of respect for proper and sustainable use of natural resources for agricultural purposes.
9. To prepare new generations of professionals at the highest academic level with the skills and tools to be leaders, innovator, problem-solvers and enhancers of the standards of agricultural production and natural resources use and conservation, positively impacting society and science in Puerto Rico and/or the countries where they work.
10. To establish and develop relationships with organizations in agricultural sciences, locally and globally, that may fortify and facilitate the training of the students and the development of the Program.

The objectives of the proposed program are in agreement with the Global Strategic Plan of the University of Puerto Rico. In particular, the program is closely related to the strategic directions of Critical Topics 6, 8, 9, 11 of that Plan.

5.2. Profile of the graduates

5.2.1. General Profile

Graduates from the Tropical Agriculture program will be expected to have the following skills:

1. Analytic capabilities, communication skills and knowledge of scientific research methods.
2. Ability to conduct independent multidisciplinary research.
3. Knowledge in agricultural, animal sciences and soil and water resource management that will permit the graduate to contribute to the improvement of the academic and professional environments of research institutions and higher education.
4. Oral and written communication skills; the capacity to formulate clear short and medium-term objectives, and the ability to publish research results in refereed journals.
5. Ability to communicate the most recent knowledge and advances in science to the agricultural sector and to the scientific community in Puerto Rico and the Caribbean.
6. Awareness of the impact of his/her research on the quality of life, including a clear understanding and respect for the legal, ethical, social, and cultural aspects of the practice of his/her profession.
7. High moral and intellectual standards that will permit the graduate to make significant contributions toward the advancement of agricultural science and natural resources management. The graduate should also strive to demonstrate ethical leadership and respect for cultural diversity and differences in opinion.

6. COMPONENTS OF THE CURRICULUM

6.1. Distribution of courses

The following are the course requirements for a doctoral degree in the proposed program. The students must have a minimum of 57 credits (100%) distributed as follows:

- ➢ 20 credits (35 %) for seven core courses
- ➢ 15 credits (26 %) for the doctoral research and thesis
- ➢ 1 credit (2 %) for the doctoral seminar
- ➢ A minimum of 21 credits (37 %) in recommended elective courses

With approval from the graduate committee of the doctoral program, up to 12 credits can be transferred from the M.S. program. A grade of A or B in the course is required for transfer. Credits from thesis research or seminars cannot be transferred. Following the current regulations of the University of Puerto Rico Mayagüez Campus, no more than 9 credits in advanced undergraduate courses (5000 level) can be used to complete requirements for courses in the doctoral program.

6.2. Description of the courses

The following graduate courses at the University of Puerto Rico Mayagüez Campus will be offered for the doctoral program in Tropical Agriculture.:

6.2.1. Core Courses (Table 6.2.1-Contact hours and credits)

CIAG 8001 – ANALYSIS OF AGRICULTURE IN THE CARIBBEAN TROPICS. Analysis of the importance of the Caribbean tropics in food production from the climatic, socio-economic, technological, and bioethical perspectives that characterize the world at present. Study of the relevance of the tropics as a source of biodiversity and in the maintenance of ecological equilibrium, and of concepts of sustainable agriculture.

CIAG 8005 – APPLIED STATISTICAL MODELS IN AGRICULTURAL RESEARCH. Study and application of statistical models in the agricultural sciences, including linear and nonlinear regression, factorial analysis of variance, mixed models and generalized linear models. Design of

experiments, analysis of data, and use of statistical software. Previous knowledge of biometry or statistics is required.

CIAN 8040 – ENVIRONMENTAL INTERACTIONS IN FARM ANIMALS. Physiological, biochemical and behavioral response of domestic animals to a variety of environmental factor such as biological, physical, chemical and social.

HORT 8030 – METHODOLOGY AND INSTRUMENTATION APPLIED TO HORTICULTURE. Study of the use and applications of methodologies and instrumentation utilized in biotechnology, hydroponics and post-harvest technology.

AGRO 6017 – Advanced Agroclimatology. Study of the use of sensors to measure and collect climatological data. Use of mathematical models to process climatological data to estimate such variables as evapotranspiration, sensible heat flux and crop canopy energy balance.

CFIT 8009 – Plant Breeding Laboratory and Field Techniques. Observation of methods and techniques used in autogamous, alogamous and asexually- propagated crops during visits to plant breeding programs in the laboratory and field. Application of laboratory and field techniques for breeding for resistance to pathogens, insects and environmental stress. Analysis of molecular and phenotypic data using computer programs.

PROC 8007 – Insect Ecology. Study and discussion of advanced concepts of insect ecology and evolution, analysis of pertinent factors at the population and community levels, and insects' interaction with the environment. Study of plant-insect, insect-insect, and parasite-insect dynamics under laboratory and field conditions.

Table 6.2.1 Core courses

Course	Codification	Title	Credits	Contact hours
CIAG	8001	Analysis of Agriculture in the Caribbean Tropics	3	Three hours of lecture per week
CIAG	8005	Applied Statistical Models in Agricultural Research	3	Three hours of lecture per week
CIAN	8040	Environmental Interactions in Farm Animals	3	Two hours of lecture and one hour of discussion per week
HORT	8030	Methodology and Instrumentation Applied to Horticulture	3	Two hours of lecture and one three-hour laboratory per week
AGRO	6017	Advanced Agroclimatology	3	Two hours of lecture and one laboratory of three hours per week
CFIT	8009	Plant Breeding Laboratory and Field Techniques	2	One hour of lecture and three-hour laboratory per week
PROC	8007	Insect Ecology	3	Two hours of lecture and one laboratory of three hours per week
TOTAL			**20**	

6.2.2. Doctoral seminar course (Table 6.2.2-Contact hours and credits)

CIAG 8925 – Doctoral Seminar. Zero to three credit hours. Oral presentation and discussion of current research topics, including the doctoral proposal and thesis research.

Table 6.2.2 Doctoral seminar course

Course	Codification	Title	Credits	Contact hours
CIAG	8925	Doctoral seminar	1	One hour of seminar per week per semester
TOTAL			**1**	

6.2.3. Doctoral dissertation course **(Table 6.2.3-Contact hours and credits)**

CIAG 8999 – Doctoral Research and Thesis. Zero to fifteen credits. Research that constitutes a significant contribution to the student's field of specialization. Writing and defense of the doctoral dissertation is required.

Table 6.2.3 Doctoral dissertation course

Course	Codification	Title	Credits	Contact hours
CIAG	8999	Doctoral Research and Thesis	15	Three hours per credit per week
TOTAL			**15**	

6.2.4. Recommended elective courses (Table 6.2.4-Contact hours and credits)

CIAN 8020 – Non-Ruminant Farm Animal Nutrition. Study of the digestive physiology of poultry, swine, equines, and lagomorphs to develop the analytical capacity for research in nutrition and its practical application. Analysis of the nutritional value of the most utilized feeds and discussion of their chemical composition, voluntary intake, digestibility, and metabolism as well as the most common feed additives.

CIAN 8025 –Vitamin Metabolism in Animals. Study of vitamins and their specific functions in animal cell metabolism. Analysis of vitamin requirements for different animal functions, the need for vitamin supplementation, and vitamin-mineral interactions.

CIAN 8630– Animal Endocrinology. Study of the organization and function of the endocrine glands. Analysis of the structure, synthesis, release, transport, and metabolism of their hormonal products and their effects on target cells.

CIAN 6601 - Advanced Animal Breeding. Advanced course in population genetics, with special emphasis on quantitative characteristics, breeding and selection of farm animals.

CIAN 6604 –Animal Nutrition. Physiological mechanisms involved in thirst and appetite; digestion, absorption and utilization of nutrients; respiration and body temperature regulation.

CIAN 6606 - Experimental Nutrition. Study and application of the methodology used in animal nutrition research. Practice in vivo, in vitro and in situ digestibility trials and mathematical models to determine ruminal degradability and fermentation rates. Evaluation of experimental designs for nutrition research.

CIAN 6611 – Ruminant Nutrition. Physiological and biochemical processes of digestion, relation of rumen function to animal Response, chemical analyses and nutrient composition and requirements of feedstuffs, primarily forages, in vitro methodology for determining nutrient digestibility.

CIAN 6617 – Advanced Reproduction. Anatomical, physiological, and pathological processes of reproduction in farm animals. Current concepts in endocrinology and their application in management and control of reproduction. Effect of tropical environment on reproduction.

CIAN 6625 – Animal Energy Metabolism. Prerequisite: Authorization of the Director of the Department. Study of energy metabolism and its relationship to cell structure; the concept and types of energy; laws of thermodynamics and their relationship to animal metabolism; energy utilization and requirements

in animals; environmental effects and control systems in energy metabolism, as well as techniques utilized for its study.

CIAN 6626 – Animal Protein Metabolism. Nutritional and biochemical aspects of animal protein metabolism; digestion and absorption; metabolism of free amino acids; protein synthesis and turnover; excretion of nitrogenous products; nutritional value of proteins; protein requirements; general features of metabolic and hormonal control.

CIAN 6637 – Neuroendocrine and Circulatory Physiology. Study of the processes of the nervous, endocrine and cardiovascular functions with emphasis on cellular control mechanisms in domestic animals.

CIAN 6638 – Renal, Respiratory and Digestive Physiology. Study of the processes of the renal, respiratory and gastrointestinal functions with emphasis in the cellular control mechanisms in domestic animals.

HORT 6620 – Production of Horticultural Crops in Protected Structures. Study of the effect of environmental factors such as light, water, humidity, temperature, carbon dioxide concentration and various nutrients sources on the growth, development and yield of horticultural crops under different protected structures.

HORT 8040 – Molecular Markers in Crops. Study of the most important molecular markers and their use in crops, with emphasis on their historical development, theoretical basis, and practical applications.

AGRO 6005 – Use of Statistical Computer Packages in Biometry. Use of statistical computer packages in the analysis of experimental data.

AGRO 6600 – Advanced Biometrics. Advanced study of analysis of variance, covariance and multiple regression, design and analysis of experiments applied to research problems in agricultural, biological and environmental sciences. Students design experiments, analyze data and use statistical computing programs. Previous knowledge of basic statistics is required.

AGRO 6300. Simulation of Agricultural Systems. Study of the principles of simulation of agricultural systems. The dynamics between crop growth and development in relation to soil water and nitrogen will be discussed. The use of models to simulate crop production and management practices will be emphasized.

AGRO 6505 - Advanced Soil Fertility. Discussion of advanced topics in soil fertility including nutritional diagnosis, nutrient availability, limiting factors, recommendations for fertilization, soil management, and environmental impact.

AGRO 6604 – Soil-Plant Relationships. Study of the process that affect root growth and development, methods of study of such processes, availability of nutrients and factors that affect their movement and absorption, growth as a function of dry matter accumulation, root proliferation and nutrient uptake.

HORT 6611 - Advanced Plant Propagation. Techniques in plant propagation through embryo culture, meristematic culture in vegetative propagation, culture of explants, and other advanced methods, review of recent findings in this field.

HORT 6616 – Advanced Tropical Fruits. A study of the problems encountered in the production of fruits of major economic importance, with special emphasis on tropical conditions. The influence of stocks, varieties, planting sites, soils and ecological factors will be stressed.

HORT 6652 – Physiology of Vegetable Crops. The study of photoperiodism, thermoperiodism, deficiencies, growth substances, rooting, germination and fruit setting in each of the major vegetable crops.

HORT 6653 – Physiology of Fruit Production. The study of fruit production, including water, light, soil and nutrition relationships; pruning fruit setting, and other growth and productivity factors.

HORT 6665 - Plant Genetic Transformation. Theory and practice of the concepts the genetic transformation of plants by direct and indirect methods. Emphasis will be given to *Agrobacterium tumefaciens* mediated transformation.

HORT 6669 - Growth Regulators in Horticulture. The use of growth regulators and other chemicals in the modification and alteration of natural plant processes; the application of these substances in the commercial production of fruits, vegetables, and ornamentals.

BIOL 6605. ENVIRONMENTAL POLLUTION AND DISTURBANCE. An ecological consideration of pollution and disturbance of the environment; the effects of industrial, domestic and other pollutants of the ecosystem; the physical, chemical and biological parameters used in pollution control and abatement. Field trips.

BIOL 6806. BIOLOGICAL SYSTEMATICS. Study of the theory and practice of biological systematics, including parsimony analysis of morphological and molecular characters. Discussion of concepts and methods pertinent to the generation and evaluation of phylogenetic trees, and their application using current software packages. A course project on the phylogeny of a particular group or organisms is required.

BIOL 6631 – Cellular Biochemistry and Physiology. The interconversions of energy in living cells, photosynthesis and carbohydrate metabolism as energy sources, the utilization of metabolic energy for protein synthesis, solute and solvent movements, nerve and muscle phenomena. Emphasis on metabolic regulation and enzyme action.

BIOL 6040. BIOGEOGRAPHY. A study of the principles governing the distribution of organisms. Examples of the Caribbean area are used.

BIOL 6369. POPULATION GENETICS. Genetic variation in natural populations of both plants and animals in different communities, covering selection, migration, mutations, mating systems, and the effect of population size on the maintenance of genetic variation.

QUIM 6815. PLANT BIOCHEMISTRY. Chemistry of plant constituents. Chemical processes occurring during the growth and development of plants; biochemistry of photosynthesis.

AGRO 6607 - Soil Chemistry. Chemical composition and properties of soils, chemical process of weathering, soil solution reaction, chemical properties of clays, and ionic exchanges in soils.

AGRO 6612 – Management of Tropical Soils. Application of principles of soil science in the interpretation and use of recent research relating to problems in the management and production of tropical soils.

AGRO 6624 - Soil Mineralogy. Identification of the constituent mineral of soils, and their relation to soil classification and agricultural practices.

BIOL 6610. LIMNOLOGY. A study of the physical, chemical and biological characteristics and interrelations of these factors in aquatic situations; community structure in still and running water; studies of local streams and ponds

ECAG 6601 – Resource Economics. Analysis of problems in the development and management of natural resources. Emphasis on natural resources in agriculture and their impact in economic development. Economic principles involved in efficient utilization of natural resources, such as water, land, sea and forest.

ECAG 6641 - Agricultural Development. Study and analysis of the factors that influence the process of transformation and development of the agricultural sector of the economy, emphasizing those of an economic nature. Emphasis is given to the situation presented by an economy in full process of development.

INCI 6006. GROUNDWATER HYDROLOGY. Fundamentals of groundwater hydrology: well hydraulics, groundwater quality, surface and subsurface factors affecting groundwater, and seawater intrusion.

INCI 6008. WATER RESOURCES SYSTEMS Systems theory and operation research for solving typical water resources problems quantitatively and qualitatively; aspects of engineering economics, the concepts of the discount rate, methods of project evaluation, stochastic and deterministic simulation.

QUIM 6215. ADVANCED ANALYTICALCHEMISTRY. Advanced topics in chemical analysis including various electrochemical, chromatographic, and complexometric methods.

CFIT 6105 – Plant Breeding Methods. Study of crop domestication and sources of genetic diversity. Application of principles of Mendelian, population, quantitative and molecular genetics in crop improvement. Study of breeding techniques in self-pollinated, cross-pollinated and asexually propagated crops, and breeding for disease and pest resistance. Analysis of the use of transgenes in crop improvement.

CFIT 6009 – Advanced Plant Genetics. Discussion of advanced concepts in classical and molecular genetics and their application to the study of genome structure, expression, and manipulation in cultivated plants.

HORT 8040 – Molecular Markers in Crops. Study of the most important molecular markers and their use in crops, with emphasis on their historical development, theoretical basis, and practical applications.

CFIT 8007 – Breeding for Biotic and Abiotic Stress in Plants. Study of biotic and abiotic factors that limit the production of crops. Application of techniques and methods of plant breeding that increase the efficiency of selection for tolerance or resistance to stress.

CFIT 6644 – Environmental Physiology. Environmental aspects of phyto-physiology, including energy, nutrition cycles, pollution, and others.

CFIT 6645 – Advances in Biological Nitrogen Fixation. Mechanism by which atmospheric nitrogen is incorporated into plant proteins and modern techniques utilized for its study, organisms capable of fixing nitrogen in a free-living state or in symbiosis with plants, methodology to take advantage of this process in agriculture.

CFIT 6611 – Advanced Plant Breeding. Types of genetic action in plant breeding, use of the principle of population genetics and quantitative genetics in the improvement of crops, relationships of population structure to the induction

of genetic variation and selectivity processes. Application cytogenetics and polyploidy concept to plant improvement.

BIOL 6617 – Advanced Genetics. Discussion of selected topics in genetics.

HORT 6665 - Plant Genetic Transformation. Theory and practice of the concepts in the genetic transformation of plants by direct and indirect methods. Emphasis will be given to *Agrobacterium tumefaciens* mediated transformation.

PROC 8016 – Advanced Plant Bacteriology. Discussion and application of principles and methods of detection, isolation, identification, and characterization of plant pathogenic bacteria. Study of pathogenesis, virulence factors, interactions, resistance, and control.

PROC 8006 – Insect Behavior. Study of the terminology and concepts of insect behavior, operating mechanisms, and its ecological and evolutionary significance. Evaluation of insect behavior and its impact on management of other populations.

BIOL 6015 - Insect Morphology. A study of the general internal and external morphology of insects.

BIOL 6637 - Taxonomy and Morphology of Fungi. A through coverage of the phycomycetes, ascomycetes, deuteromycetes and basidiomycetes from a taxonomical and morphological approach, with emphasis on saprophytes, zoopathogens and phytopathogens.

PROC 6015 - Molecular Aspects in Phytopathology. Study of the biochemistry, physiology, and molecular biology of plant-pathogen interactions. Discussion of molecular mechanisms involved in the development of plant diseases caused by biotic agents such as fungi, bacteria, nematodes and viruses.

PROC 6603 – Methods of Research in Pathology. A course intended to give the graduate student practice and skills in methods of laboratory and field research in plant pathology.

PROC 6604 – Diagnosis and Control of Plant Diseases. Techniques used in diagnosis of plant diseases, sources of descriptive information on phytopathogens, fungi identification, and control measures.

PROC 6606 – Epidemiology of Plant Diseases. Application of mathematical analysis to the field study of plant disease epidemics. The use of forecasting and methods of detecting and quantifying the effects of epidemics on the yield and quality of crops.

PROC 6608 – Advanced Tropical Phytopathology. Study and analysis of the etiology, pathology, epiphytology, and control of major plant diseases of the most important economic tropical crops.

PROC 6609 – Integrated Pest Management. Integrated management of agricultural pests based on the understanding of basic ecological principles and through the use of environmentally compatible pest management tactics and strategies which include ecological management, and the biological, mechanical, genetic, chemical and legal factors.

PROC 6625 – Taxonomy and Morphology of Entomophagous Insects. Analysis, application, and evaluation of methods used in the morphology, taxonomy and systematics of entomophagous insects with emphasis on hymenopterans. Includes character differentiation, the construction and evaluation of keys, cladograms, and phenograms, analysis of the literature, and the taxonomy and morphology to the family level.

PROC 6630 – Control of Phytoparasitic Nematodes. Study and evaluation of the physical, biological and chemical control of phytoparasitic nematodes.

PROC 6635 – Tropical Agro-nematology. A detailed study covering the most important aspects of plant nematodes in the tropics, especially those concerned with sugar cane, coffee, tobacco, citrus fruits, pineapple, plantains, bananas, rice, and vegetables.

PROC 6645 - Biological Control: Concepts and Theories. Ecological theories which study the use of beneficial organisms for the population density regulation of organisms noxious to crops of economic importance. Other topics to be studied are: structure of the agroecosystem community, predator-prey ecological relations, types and components of predation, post-introduction programs and aspects of integration, perspectives and development of biological control strategies.

PROC 6650 – Phytovirology. Fundamental concepts of plant viruses including transmission vector identification, their effects on insect vectors, host range, classification, serology and physical properties and methods of control. Research methods are emphasized in the laboratory.

ECAG 6604 –Advanced Farm Management. Analysis of situations and problems related with management of farm businesses. Includes study and analysis of methods of collecting and analyzing farm data; marginal analysis and budgeting techniques; and managerial concepts as they apply to all levels of decision-making.

ECAG 6611 – Economics of Agricultural Production. Economic analysis of agricultural production. Includes the study of production and cost functions;

input-output analysis; and the decision-making process necessary for a proper utilization of resources.

ECAG 6631 – Advanced Agricultural Marketing. A comprehensive advanced study of the field of agricultural marketing.

ECAG 6635 – Global Agribusiness Marketing. Analysis of the different marketing strategies used by agribusiness organizations in the global market.

ECAG 6650 – Economics of Agricultural Policy. General comprehensive study of the formulation and implementation of policy for the agricultural sector of the economy, with major emphasis on the economic aspects. Reference is made to specific aspects of policy, especially in Puerto Rico and the United States.

ECAG 6654 –Rural Sociology Problems. The application of sociological theories to the analysis of rural social problems; investigation of factors detrimental to community development and human welfare.

ECAG 6660 –Agricultural Prices. A cross-section analysis of the factors affecting demand and product prices; study of empirical techniques of economic model building and interpretation, and of forecasting.

ECAG 6665 – Applied Econometrics I. Use of econometrics in the agricultural economics problems and its application in production, price and consumption models.

ECAG 6666 – Applied Econometrics II. Study, application and evaluation of econometric models with limited dependent variables. Analysis and interpretation of results based on regression models.

EDAG 6601 - Advanced Methods in Teaching Vocational Agriculture. A comparative study of teaching methods and techniques.

EDAG 6603 - Evaluation. Study of the fundamentals of tests and measurements. Emphasis will be given to measures of central tendency and dispersion, measures for comparing differences and significance of the difference at various confidence levels, interpretation of results and formulation of plans of action.

EDAG 6608 – Preparation of Teaching Material. The preparation by the students of teaching materials such as samples, specimens, charts, graphs, pictures, slides, job analyses, lesson plans, basic units and enterprise units.

EDAG 6671 - Program Planning. A detailed analysis of the job of the teacher of vocational agriculture, with emphasis on the development of a sound philosophy of the program of instruction and the work.

EXAG 6603 – Oral and Written Communication. The learning process and the principles involved in written and oral communication. The course is especially designed for extension agents, teachers of vocational agriculture, and others interested in improving their teaching abilities, laboratory practice in the arts of communication is provided.

EXAG 6610 – Principles of Extension Teaching. The theories and principles of teaching and learning, and their application to Agricultural Education and Extension.

EXAG 6620 - Extension Evaluation. A study of the principles involved in extension evaluation, and of adequate methods and processes for measuring and evaluating extension work according to the results obtained. Questionnaire construction, sampling, interviewing, and analysis and interpretation of data will be discussed.

EXAG 6622 - Program Development in Extension. The basic principles, procedures and problems in the process of extension program development in both agriculture and homemaking.

EXAG 6628 - Advanced Seminar in Extension Problems. Study of problems from such fields as administration, supervision, personnel recruitment and training, and scope of programs. Selection will be made in the light of the special interest of seminar members.

CITA 6017 - Food Toxicology. Study of the formation, characteristics, and control of potentially toxic components that occur naturally or are induced during food processing.

CITA 6016 - Sensory Properties of Food. Study of the descriptive and qualitative aspects of sensory analysis of food. Discussion and application of methodology for data collection and analysis. Group projects are required.

CITA/HORT 6603 - Food Processing Laboratory I. The topics in the laboratory will include tray drying, freeze drying, freezing, canning, heat penetration process studies in canned products, and fermentation.

CITA/HORT 6601 - Food Processing I. Fundamentals and commercial practice of food preservation by heat treatment, drying, freezing, canning, irradiation and microwaves. Topics included are selection of raw material, preparation, unit of operations and processing, packaging and storage. Processes covered will include aseptic packaging of juice and milk as well as canning of fruits and vegetables.

CITA 6615 - Food Technology. Units of operations: filling and packaging, reverse osmosis, ultrafiltration, electrodialysis, evaporation, freeze concentration. Quality control of raw materials and finished products, laws and regulations that apply to food industry.

HORT/CITA 6007 – Safety of Fruit and Vegetable Products. Advanced study of intrinsic and extrinsic factors that determine the growth of microorganisms, during postharvest, processing, storage, and transportation of fruits and vegetables that may affect public health.

HORT 6650 - Post Harvest Physiology and Manipulation of Horticultural Crops. The physiology of maturation and ripening, and the handling of the physiology of maturation and ripening, and the handling of horticultural crops to preserve quality and ensure storage life.

BIOL 6705 - Advanced Food Microbiology. Microbiology of food commodities. The nature and function of beneficial and harmful microorganisms. Food borne diseases. Effects of food processing and storage on microorganisms.

Table 6.2.4 Recommended elective courses.

Course	Codification	Title	Credits	Contact hours
CIAN	8020	Non-ruminant farm animal nutrition	3	Three hours of lecture per week
CIAN	8025	Vitamin metabolism in animals	3	Three hours of lecture per week
CIAN	8630	Animal Endocrinology	3	Two hours of lecture and one hour of discussion per week
CIAN	6601	Advanced Animal Breeding	3	Three hours of lecture per week
CIAN	6604	Animal Nutrition	3	Two hours of lecture and one three hour laboratory per week
CIAN	6606	Experimental Nutrition	3	Two hours of lecture and one three hour laboratory per week
CIAN	6611	Ruminant Nutrition	3	Two hours of lecture and one three hour laboratory per week

CIAN	6617	Advanced Reproduction	3	Three hours of lecture per week
CIAN	6625	Animal Energy Metabolism	3	Three hours of lecture per week
CIAN	6626	Animal Protein Metabolism	3	Three hours of lecture per week
CIAN	6637	Neuroendocrine and Circulatory Physiology	3	Three hours of lecture per week
CIAN	6638	Renal, respiratory and Digestive Physiology	3	Three hours of lecture per week
HORT	6620	Production of Horticultural Crops in Protected Structures	3	Three hours of lecture per week
HORT	8040	Molecular Markers in Crops	3	Two hours of lecture and one three-hour laboratory per week
AGRO	6005	Use of Statistical Computer Packages in Biometry	2	Two hours of lecture per week
AGRO	6600	Advanced Biometrics	3	Two hours of lecture and three hours of laboratory per week
AGRO	6300	Simulation of Agricultural Systems	3	Three hours of lecture per week
AGRO	6505	Advanced Soil Fertility	3	Three hours of lecture per week
AGRO	6604	Soil-Plant Relationships	3	Three hours of lecture per week
HORT	6611	Advanced Plant propagation	3	Two hours of lecture and one three-hour laboratory per week
HORT	6616	Advanced Tropical Fruits	3	Three hours of lecture per week

HORT	6652	Physiology of vegetables crops	3	Three hours of lecture per week
HORT	6653	Physiology of fruit production	3	Three hours of lecture per week
HORT	6665	Plant Genetic Transformation	4	Three hours of lecture and one four-hour laboratory per week
HORT	6669	Growth regulators in horticulture	3	Two hours of lecture and one three-hour laboratory per week
BIOL	6605	Environmental Pollution and Disturbance		Three hours of lecture per week
BIOL	6806	Biological Systematics	3	Three hours of lecture per week
BIOL	6631	Cellular Biochemistry and Physiology	4	Three hours of lecture and one three hour laboratory per week
BIOL	6040	Biogeography	3	Three hours of lecture per week
BIOL	6369	Population Genetics	3	Three hours of lecture per week
QUIM	6815	Plant Biochemistry	3	Three hours of lecture per week
AGRO	6607	Soil Chemistry	3	Two hours of lecture and one three-hours laboratory per week
AGRO	6612	Management of Tropical Soils	3	Three hours of lecture per week
AGRO	6624	Soil Mineralogy	3	Two hours of lecture and one three-hours laboratory per week
BIOL	6610	Limnology	3	Two hours of lecture and one three-hours laboratory per week

ECAG	6601	Resources Economics	3	Three hours of lecture per week
ECAG	6641	Agricultural Development	3	Three hours of lecture per week
INCI	6006	Groundwater Hydrology	3	Three hours of lecture per week
INCI	6008	Water Resources Systems	3	Three hours of lecture per week
QUIM	6215	Advanced Analytical Chemistry	3	Three hours of lecture per week
CFIT	6105	Plant Breeding Methods	3	Three hours of lecture per week
CFIT	6009	Advanced Plant Genetics	3	Three hours of lecture per week
HORT	8040	Molecular Markers in Crops	3	One hour of lecture and three-hour laboratory per week
CFIT	8007	Breeding for Biotic and Abiotic Stress in Plants	3	Three hours of lecture per week
CFIT	6644	Environmental Physiology	3	Two hours of lecture and one hour of seminar per week
CFIT	6645	Advances in Biological Nitrogen Fixation	3	Three hours of lecture per week
CFIT	6611	Advanced Plant Breeding	3	Three hours of lecture per week
BIOL	6617	Advanced Genetics	3	Two hour of lecture and one laboratory of three hours per week
HORT	6665	Plant Genetic Transformation	4	Three hours of lecture and one laboratory of three hours per week

PROC	8016	Advanced Plant Bacteriology	3	Two hours of lecture and one laboratory of three hours per week
PROC	8006	Insect Behavior	3	Two hours of lecture and one laboratory of three hours per week
BIOL	6015	Insect Morphology	4	Two hour of lecture and two four-hours laboratories per week
BIOL	6637	Taxonomy and Morphology of Fungi	3	Two hour of lecture and one laboratory of three hours per week
PROC	6015	Molecular Aspects in Phytopathology	3	Three hours of lecture per week
PROC	6603	Methods of Research in Pathology	4	Two hour of lecture and two three-hour laboratories per week
PROC	6604	Diagnosis and Control of Plant Diseases	3	One hour of lecture and two laboratory of three hours per week
PROC	6606	Epidemiology of Plant Diseases	3	Two hour of lecture and one laboratory of three hours per week
PROC	6608	Advanced Tropical Phytopathology	4	Four hours of lecture per week
PROC	6609	Integrated Pest Management	3	Two hours of lecture and one laboratory of three hours per week
PROC	6625	Taxonomy and Morphology of Entomophagous Insects	4	Three hours of lecture and one laboratory of three hours per week
PROC	6630	Control of Phytoparasitic Nematodes	3	Two hours of lecture and one laboratory of three hours per week
PROC	6635	Tropical	3	Two hours of lecture and

		Agronematology		one laboratory of three hours per week
PROC	6645	Biological Control: Concepts and Theories	3	Two hours of lecture and one laboratory of three hours per week
PROC	6650	Phytovirology	3	Two hours of lecture and one laboratory of three hours per week
ECAG	6604	Advanced Farm Management	3	Three hours of lecture per week
ECAG	6611	Economics of Agricultural Production	3	Three hours of lecture per week
ECAG	6631	Advanced Agricultural Marketing	3	Three hours of lecture per week
ECAG	6635	Global Agribusiness Marketing	3	Three hours of lecture per week
ECAG	6650	Economics of Agricultural Policy	3	Three hours of lecture per week
ECAG	6654	Rural Sociology Problems	3	Three hours of lecture per week
ECAG	6660	Agricultural Prices	3	Three hours of lecture per week
ECAG	6665	Applied Econometrics I	3	Three hours of lecture per week
ECAG	6666	Applied Econometrics II	3	Three hours of lecture per week
EDAG	6601	Advanced Methods in Teaching Vocational Agriculture	3	Three hours of lecture per week
EDAG	6603	Evaluation	3	Three hours of lecture per week
EDAG	6608	Preparation of Teaching Material	3	Three hours of lecture per week

EDAG	6671	Program Planning	3	Three hours of lecture per week
EXAG	6603	Oral and Written Communication	3	One hour of lecture and two three-hour laboratory periods per week
EXAG	6610	Principles of Extension Teaching	3	Three hours of lecture per week
EXAG	6620	Extension Evaluation	3	Three hours of lecture per week
EXAG	6622	Program Development in Extension	3	Three hours of lecture per week
EXAG	6628	Advanced Seminar in Extension Problems	3	Three hours of lecture per week
CITA	6017	Food Toxicology	3	Three hours of lecture per week
CITA	6016	Sensory Properties of Food	3	Two hours of lecture and one three-hour laboratory per week
CITA/ HORT	6603	Food Processing Laboratory I	1	One four-hour laboratory per week
CITA/ HORT	6601	Food Processing I	3	Three hours of lecture per week
CITA	6615	Food Technology	3	Two hours of lecture and one three-hour laboratory per week
CITA/ HORT	6007	Safety of Fruit and Vegetables Products	3	Two hours of lecture and one three-hour laboratory per week
HORT	6650	Post Harvest Physiology and Manipulation of Horticultural Crops	3	Two hours of lecture and one three-hour laboratory per week
BIOL	6705	Advanced Food Microbiology	3	Two hours of lecture and one three-hour laboratory per week

6.3. Curriculum Sequence

This curriculum sequence concurs with the distribution of courses mentioned in section 6.1 and the graduate course offerings scheme presented in section 6.2.

First semester:	● CIAG8005 Applied Statistical Models in Agricultural Research (3 credits) ● HORT8030 Methodology and Instrumentation Applied to Horticulture (3 credits) ● Recommended elective course (3 credits)
Second semester:	● CIAN8040 Environmental Interactions in Farm Animals (3 credits) ● AGRO6017 Advanced Agroclimatology (3 credits) ● Recommended elective course (3 credits)
Third semester:	● CIAG8001 Analysis of Agriculture in the Caribbean Tropics (3 credits) ● CFIT8009 Plant Breeding Laboratory and Field Techniques (3 credits) ● Recommended elective course (3 credits) ● Doctoral seminar (0 credit)
Fourth semester:	● PROC 8007 Insect Ecology (2 credits) ● Recommended elective course (2 credits) ● Recommended elective course (3 credits) ● Doctoral dissertation (1 credits) ● Doctoral seminar (0 credit)
Fifth semester:	● Doctoral dissertation (2 credits) ● Doctoral seminar (0 credit) ● Recommended elective course (3 credits)
Sixth semester:	● Doctoral dissertation (2 credits) ● Doctoral seminar (0 credit) ● Recommended elective course (3 credits)
Seventh semester:	● Doctoral seminar (1 credit) ● Doctoral dissertation (5 credits)
Eighth semester:	● Doctoral dissertation (5 credits)

6.4. Relation of the proposed curriculum to the graduate profiles

To comply with the profiles described in section 5.2, students will take courses during the first two years. In the third year, students will take integrated courses, which will provide a global perspective of problems in agriculture, and the research needed to solve said problems. The remaining time will be dedicated to research for the dissertation and to related activities (seminars, presentations in scientific forums and publications).

Table 6.4. Matrix of the proposed curriculum to the graduate profile.

	Mission	**Philosophy**	**Goal**	
Graduate Profile	Prepare competent researchers, innovators and leaders, capable of generating new in tropical environments	Develop the cognitive skills necessary to make significant contributions to the agricultural sciences that will lead to benefits for the agricultural sector, the government and for society	Prepare highly skilled and ethical professionals in tropical conditions, capable of solving existing problems and generating new information and technology to expand basic and applicable knowledge related to agriculture, natural resources, and food science and technology.	**Semester**
Analytic capabilities, communication skills and knowledge of scientific research methods.	4	3	1, 2	1-8
Ability to conduct independent multidisciplinary research.	4	4	1,	1-8
Knowledge in agricultural sciences and	1, 2	4	1, 2	1-8

natural resource management that will permit the graduate to contribute to the improvement of the academic and professional environments of research institutions and higher education.				
Oral and written communication skills; the capacity to formulate clear short and medium-term objectives, and the ability to publish research results in refereed journals.	4	4	1, 2	1-8
Ability to communicate the most recent knowledge and advances in science to the agricultural sector and to the scientific community in Puerto Rico and the Caribbean.	3	4	1, 2	1-8
Awareness of the impact of his/her research on the quality of life, including a clear understanding and respect for the legal, ethical, social, and cultural aspects of the practice of his/her profession.	4	4	4	1-8
High moral and intellectual standards that will permit the graduate to make significant	1, 2	4	4	1-8

contributions toward the advancement of agricultural science and natural resources management. The graduate should also strive to demonstrate ethical leadership and respect for cultural diversity and differences in opinion.				

1=Core courses
2=Recommended elective courses
3=Doctoral Seminar
4=Doctoral dissertation
1-8=Semesters where student could take the course

6.5. Educational methodology and instruction strategies

The educational methodology in the doctoral program in Tropical Agriculture is directed toward the fulfillment of the objectives of the program and completely align with the strategies and educational activities in the curriculum sequence. Different educational strategies will be used for the teaching and learning process: lectures, laboratories, field trips, independent study, collaborative learning and work in research teams. The ability to work independently will be emphasized through assignments and reports that will be required in some of the courses. The ability to conduct work and learn collaboratively as part of a team will be enhanced by means of required projects and complex problems demanding that several students work together to find an acceptable solution. Seminars will be given to help students to improve research and study techniques, to conduct independent research and to give effective academic presentations. The dissertation will be used to help the student develop the capacity to conduct relevant research and to effectively communicate the results to the academic community. Some of the courses from the Department of Agricultural Economics could be part of the curricular sequence of the Doctoral Program.

The Agricultural Experimental Station Library maintains, yearly, the subscription of the Access Digital Library Database of the Alliance of Crop, Soil and Environmental

Science Societies (https://dl.sciencesocieties.org) and provides access to 88 different databases at http://libguides.uprm.edu/az.php?s=96802.

7. Admission and enrollment

7.1. Requirements for admission to the proposed program and current norms for admission

Admission of students to the doctoral program in Tropical Agriculture will comply with the general requirements established by the regulations of graduate studies of the University of Puerto Rico Mayagüez Campus (Certification 09-09, as amended http://grad.uprm.edu/cert.pdf). A copy of this certification is included in Appendix H. The admission process will have the following steps:

1. A request for admission and other documentation required by the Office of Graduate Studies which will be submitted within the period established on the academic calendar;
2. The Office of Graduate Studies will send the documents to the Graduate Committee of the doctoral program;
3. The Graduate Committee of the doctoral program will evaluate the request for admission and submit a recommendation to the Dean of the Faculty for his/her decision; and
4. The Office of Graduate Studies will notify the applicant of the decision.

Among the factors to be considered for admission are the academic transcript, professional experience, personal qualities and goals of the applicant. The candidates will be selected by competition among those individuals who satisfy the minimum general requirements for admission as stated on page 69 of the Graduate Catalog 2018-2019 of the University of Puerto Rico Mayagüez Campus (http://academico.uprm.edu/cms/index.php?a=file&fid=17508)). All admissions will be subject to the availability of an advisor and funds to support the research.

A prospective student for this program may apply having a BS in Agricultural Sciences or similar discipline. It is generally desirable that before enrolling in the doctoral program, the student earns a master's degree from an accredited University in Sciences or its equivalent with a major in Agriculture, Environmental Sciences, General Science, Chemistry or Biology. A minimum GPA of 3.25 is required for Science courses under the aforementioned disciplines, and GPA of 3.00 in other discipline courses. The applicant must have at least 9 credits in Agricultural Sciences related courses such as courses code in General Agriculture, Animal Sciences, Agronomy, Soil Sciences, Plant Science, Horticulture and Crop Protection. In addition, applicants must have at least 3 credits in Biostatistics or equivalent courses. Students will be accepted with a maximum of 4 courses on deficiencies and will be encourage to fulfill deficiencies requirements through professional development.

Applicants will be required to take the general Graduate Record Exam (GRE) and the *Examen de Admisión a Estudios de Posgrado* (EXADEP) taken within three years prior application to graduate school. The scores from verbal and quantitative portions of the exam will be considered. The applicant must submit a 2-page CV along with a short essay (max. 1,000 words) indicating short and long-term goals. The essay must include applicant's research experience, interests and potential contribution of research goals to foster Tropical Agriculture. It is expected that the applicant has adequate spanish and english language proficiency in both oral and written forms. The Graduate Committee (GC) of the doctoral program will assess the result of this general requirement along with a face to face interview with the applicant. The GC may recommend conditional admission if all requirement are not met.

7.2. Enrollment projections for the first five years

Given the interdisciplinary scope of the proposed graduate program, it is anticipated that applicants will come from agricultural sciences, biological sciences, engineering and other related areas. Similarly, it is expected that students from the Caribbean Basin, Latin America, the United States and other countries with either Spanish or English as main language will be interested in the program. Given that 77% of Faculty members have a Ph.D. and the level of research in the College of Agricultural Sciences have reached up to

155 Research Projects with External Funding during FY 2018-19. Eighty percent of the projects have the capability to provide graduate assistantship. It is expected that six to eight students per year could be admitted to the proposed doctoral program during the first five years with an enrollment projections as presented on Table 7.2.1.

Table 7.2.1 Enrollment projection for the first five year

Enrollment projection					
	1 YEAR	2 YEAR	3 YEAR	4 YEAR	5 YEAR
Number of students	8	16	24	20	20

To encourage faculty members to serve as Director of Dissertation, up to 3 credits in regular academic load will be permitted. Plans to strengthen the faculty and to increase the level of research in the College of Agricultural Sciences should allow more students to be admitted to the program. Recruitment will be promoted by social media and official web pages. In addition, the Office of International Programs of the CAS will actively help promote enrollment of foreign students in the doctoral program, through participation in international activities such as professional meetings and visits to universities and other organizations with potential students to be recruited.

8. ACADEMIC REQUIREMENTS TO CONFER A DEGREE

The academic requirements for the proposed degree are described in the following sections.

8.1. Total number of course credit hours required

The Doctor of Philosophy degree will require the completion of a minimum of 57 credits (100%) distributed as follows:

- 20 credits (35 %) for seven core courses
- 15 credits (26 %) for the doctoral research and thesis
- 1 credit (2 %) for the doctoral seminar

➢ A minimum of 21 credits (37 %) in recommended elective courses

Up to 12 credits can be transferred from the M.S. program

8.2. Minimum grade point average

As indicated in section 8.1, a student must complete a minimum of 57 credit hours of courses to obtain the doctorate. The student must earn an A or B in all of the courses.

8.3. Number of credits to be accepted as transfer

The total number of credits to be accepted as transfer credits will be determined by the Graduate Committee of the Doctoral Program. However, no more than 12 credits from **graduate programs** at the University of Puerto Rico, Mayagüez Campus or other comparable institutions of higher education can be transferred. The student must have earned at least a B in the courses for which credit is to be transferred.

8.4. Residence

Residence requirements will follow the regulations of the Office of Graduate Studies of the University of Puerto Rico Mayagüez Campus (http://grad.uprm.edu/cert.pdf Appendix E).

8.5. Seminar

Doctoral students could be required by their committee to take one credit of doctoral-level seminar. Students enrolled in seminar will select a research topic for a formal public oral presentation. Well-known researchers from the University of Puerto Rico Mayagüez Campus and other institutions will participate in the seminar course through presentations, contributions and attendance.

8.6. Written qualifying exam

Upon satisfactory completion of at least 36 credits after being admitted to the doctoral program, all doctoral students will be required to take a written qualifying exam. The

purpose of the exam is to evaluate the competence of the student. The Graduate Committee of the Program, in collaboration with the Student's Graduate Committee, will prepare the exam and establish the level of proficiency required for passing the exam. Following the norms of graduate studies of the University of Puerto Rico Mayagüez Campus, the student will have two opportunities to pass the exam.

8.7. Oral candidacy exam

After passing the written qualifying exam, the student will also take an oral candidacy exam in which the research proposal will be presented and defended before his/her Graduate Committee. If the Graduate Committee agrees that the student has passed the exam, he/she will become a **doctoral candidate**. Following the norms of graduate studies of the University of Puerto Rico Mayagüez Campus, the student will have two opportunities to pass the exam.

8.8. Dissertation

The doctor of philosophy degree is conferred for distinguished academic achievement and a significant and original contribution to the student's area of knowledge. All doctoral candidates must prepare an original publishable dissertation describing a topic of research. The dissertation must demonstrate that the student understands the topic, is capable of conducting research that represents a significant, and can effectively communicate the results to the academic community. Upon completion of all of the requirements for the degree, the doctoral candidate must successfully defend his/her dissertation.

8.9. Language requirements

Students in the doctoral program must be able to communicate in both Spanish and English. If a student lacks adequate skills in either language, he/she will be encouraged to enroll in appropriate remedial courses. There will be no additional language requirements.

8.10. Time limit for completing the degree

In accordance with the norms of graduate studies of the University of Puerto Rico Mayagüez Campus, doctoral students who enter the program with a master's degree should

complete the requirements for a Ph.D. degree within 3-4 years, and doctoral students who enter the program with a bachelor's degree should complete the requirements for a Ph.D. degree within 6-8 years.

9. FACULTY

9.1. Faculty needed to establish the program

The College of Agricultural Sciences has all the scientific and academic personnel needed to establish a doctoral program of excellence. Academic personnel in the doctoral program should strive to have the ability to publish articles in refereed journals (Appendix F shows recent publications of participating faculty); the willingness to actively conduct scientific research and participate in national and international conferences; the capability to obtain external funds for research by submitting proposals for competitive grants (Appendix G shows a list of active research projects); and an interest in gaining experience in teaching graduate courses and directing thesis research. These elements are indicators of excellence for the professional success of academic personnel and their capacity to insure that the graduates from the Doctoral Program are well prepared academically and professionally. In particular, the presidents of the graduate committees should demonstrate continuity in their research programs to be able to cover the costs involved in the successful completion of the research required for a doctoral dissertation. Presidents of graduate committees will be required to have at least the rank of associate professor, or its equivalent, and to have demonstrated continuity in their research programs, active participation on research congress, institutional committees and online continuing education.

All academic personnel who will participate in the doctoral program are qualified. Appendix H includes the Curriculum Vitae of the current academic personnel who could participate in the program. Table 9.1 presents a list of professors with doctoral degrees in the College of Agricultural Sciences having academic appointments per each program to be offered. Professors whose academic background and research area are able to accomplish in both programs were classified as interdisciplinary. The doctoral program is also supported by professors from other disciplines (engineering, biology, and chemistry,

among others). Professors listed in Table 9.1 will be in charge of offering the courses for each one of the disciplines. All other courses are in charge by professors classified as interdisciplinary

Table 9. 1. Summary of the academic preparation, area of specialization and Ph.D. granting institution and Program of faculty in the College of Agricultural Sciences that may participate in the Doctoral Program in Tropical Agriculture, academic year 2019-2020.

Name	Degree-Rank	University	Specialization
Animal Science Program			
Curbelo, Jaime E.	PhD-Assoc. Prof.	Mississippi State University	Dairy Science - Production
Domenech, Katherine	PhD-Asst. Prof.	University of Nebraska	Meat Science & Food Technology
Fernández, John	PhD-Prof.	University of Kentucky	Animal Reproductive Physiology
Jiménez, Esbal	PhD-Assoc. Res.	Ohio State University	Swine Reproduction, Physiology
Latorre, José R.	PhD-Prof.	University of Arkansas	Poultry Science
Mesonero, Alexander	DVM, MS-Assoc Prof.	Louisiana State University	Vet. Pathology Physiology, Animal Health
Ortiz, Guillermo	PhD-Assoc. Prof.	Michigan State University	Growth Physiology, Ruminant Nutrition, Dairy Science
Pagan, Suzika	PhD- Assoc. Prof	Texas A&M	Agronomy/Animal Nutrition
Pagán, Melvin	PhD-Prof.	Michigan State University	Molecular Genetics
Ponce de León, Leyda	PhD – Assoc. Prof.	University of Wisconsin	Milk Tech. & Production
Rodríguez, Abner A.	PhD-Prof.	Michigan State University	Ruminant Nutrition - Microbiol.
Ruíz, Teodoro	PhD-Prof.	University of Florida	Dairy Nutrition - Forages
Sánchez, Héctor L.	PhD-Asst. Prof.	Mississippi State University.	Dairy Science, Physiology
Santana, Carmen S.	PhD-Assoc. Prof.	University of Illinois	Swine Mgt. – Animal Behavior
Santiago, Héctor L.	PhD-Prof.	Virginia Polytechnic Institute	Poultry Science– Animal Growth
Siberio, Víctor	PhD-Prof.	Michigan State University	Swine Mgt. - Non-ruminant Nutrition
Plant Science Program			

Name	Degree-Rank	University	Specialization
Abelleira, Oscar J.	PhD-Asst. Prof.	University of Idaho	Natural Resources & Forestry
Aponte, Alfredo	PhD-Asst. Prof.	North Dakota State University	Forages and Dedicated energy crops
Chong, Joaquín A.	PhD–Asst. Prof.	Clemson University	Physiology of Ornamentals
Estévez, Elva C.	PhD-Asst. Res.	University of Minnesota	Plant Pathology
Feliciano, Merari	PhD-Asst. Prof.	University of Kentucky	Phytopathology
Franqui, Rosa A.	PhD-Prof.	University of Wisconsin	Entomology
Gallardo, Fernando	PhD-Prof.	Louisiana State University	Entomology
Giraldo, Martha C.	PhD- Assoc. Prof.	Kansas State University	Plant Pathology
González Gill, Lizzette	PhD –Prof.	Rutgers University	Plant Physiology
Hernandez, Ermita	PhD-Assist. Prof.	Pennsylvania State University	Plant Science, Horticulture
Linares, Angela	PhD-Asst. Prof.	North Dakota State University	Crop Management & Genetics
Lugo, María de L.	PhD-Prof.	University of Arkansas	Weed Science
Martinez, Edda	PhD- Aux. Prof	Mississippi State	Insect Taxonomy and Systematic
Morales, José Pablo	PhD-Prof.	University of Florida	Fruit Science, Organic Agriculture
Ortiz, Carlos E.	PhD-Prof.	University of Arkansas	Plant Breeding & Genetics
Rivera, Dania	PhD-Assoc. Prof.	Ohio State University	Plant Science- Horticulture
Rivera, Lydia I.	PhD-Prof.	Ohio State University	Plant Pathology
Robles, Wilfredo	PhD-Assoc. Prof.	Mississippi State University	Weed Science
Román, Elvin	PhD-Prof.	Kansas State University	Crop Management
Román, Félix R.	PhD-Prof.	University of Nebraska	Inst. Analysis–Environmental Contam.
Rosario, Carlos	PhD-Prof.	Pennsylvania State University	Urban Entomology
Segarra, Alejandro	PhD-Prof.	University of Maryland	Entomology
Torres, Ramón I.	PhD-Prof.	Texas A&M University	Plant Physiology
Vargas, Roberto	PhD-Prof.	Auburn University	Nematology
Viteri, Diego	PhD-Asst. Prof.	University of Idaho	Plant Breeding & Genetics

Soil and Water Resources Management			
Flores, Mario	PhD-Assoc.Prof.	University of Wisconsin	Soil Physics
Martínez, Gustavo	PhD-Prof.	Ohio State University	Soil Chemistry
Muñoz, Miguel A.	PhD-Prof.	Ohio State University	Soil Science
O'Hallorans, Julia	PhD-Assoc. Prof.	New Mexico State University	Soil Fertility
Sánchez, Yaniria	PhD-Prof.	University of Idaho	Soil Biology
Pérez, Luis R.	PhD-Prof.	Pennsylvania State University	Environmental Agric. Engineering
Snyder, Víctor	PhD-Prof.	Cornell University	Soil Physics
Sotomayor, David R.	PhD-Prof.	Kansas State University	Soil Fertility
Tirado, Rebecca	PhD-Assoc. Prof.	Ohio State University	Soil Science
Interdisciplinary			
Chávez, Rosa N.	PhD-Prof.	University of Sao Paulo, Brazil	Food Science
Comas, Myrna	PhD-Prof.	University of PR-Río Piedras	International Business
Dumas, José A.	PhD-Prof.	University of PR-Río Piedras	Chemistry
González, Gladys M.	PhD – Prof.	Univ. of Missouri Columbia	Economics of Natural Resources
Gregory Alexandra	PhD-Assoc. Prof.	Kansas State University	Agricultural Economics
Harmsen, Eric W.	PhD-Prof.	University of Wisconsin	Agricultural Engineering
Hernández, Julio C.	PhD-Assist. Prof.	Western Michigan University	Applied Economics
Huertas, Javier A.	PhD-Asst. Ext. Sp.	University of PR-Mayagüez	Chemical Engineering
Jiménez, Alwin J.	PhD-Prof.	Pennsylvania State University	Agric. Environmental & Regional Economics
Macchiavelli, Raúl E.	PhD-Prof.	Pennsylvania State University	Statistics & Biometry
Mathanker, Sunil K.	PhD-Assist. Prof.	Oklahoma State University	Biosystems Engineering

Monroig, Francisco M.	PhD-Prof.	Purdue University	Agricultural Engineering
Orellana, Lynette	PhD-Assoc. Prof.	Washington State University	Food Science
Padilla, David	PhD-Prof.	Ohio State University	Agricultural Education and Extension - Statistics
Perales, Oscar, J.	PhD-Prof.	Tohoku University, Japan	Materials Science and Engineering
Pérez, Fernando J.	PhD-Assoc. Prof.	Iowa State University	Food Processing Engineering
Plaza, María L.	PhD—Asst. Prof.	University of Florida	Food Science
Ramos, Germán	EdD-Asst. Prof.	University of PR-Río Piedras	Sustainable Community Development
Resto, Pedro	PhD-Prof.	Texas A&M	Industrial Engineering
Ríos, Carlos	PhD-Prof.	University of Wisconsin	Bacteriology
Rodrigues, José C.	PhD-Prof	University of Florida	Virology
Rodríguez, María del C.	PhD-Prof.	Cornell University	Human Nutrition
Rodríguez, Robinson	PhD-Prof.	State University of New York	Political Sociology- Poverty and Inequality
Santana, Julio	PhD-Prof.	Ana G Mendez Turabo	Biosystems
Santiago, Edly	PhD-Assoc. Prof.	Pennsylvania State University	Agric. and Env. Education
Silva, Luis F.	PhD-Prof.	Cornell, University	Int. Agric., Comm. & Leadership
Tavaréz, Héctor S.	PhD-Asst. Prof.	University of Idaho	Environmental Economics
Valencia, Elide	PhD-Prof.	University of Florida	Forage Management
Vivoni, Carlos A.	PhD-Prof.	University of Massachusetts	Distance Education

9.2. Projections for the Faculty for the next five years

The College of Agricultural Sciences had an enrollment of 1,674 undergraduate students and 197 graduate students in 2019, being one of the few schools within the RUM with sustained growth. The students were attended in the different courses offered and we were able to attend many more if we had more teachers to offer the courses, mainly in the graduate programs. For example, the Department of Agricultural Education only has 3

teachers to meet the needs of the program and especially for the preparation of teachers in agriculture for the agriculture program of the department of education. This department served 840 students in 2018-2019. It is necessary to strengthen this department with at least one teacher in curriculum who can strengthen the undergraduate and graduate program. It is extremely important to point out that 50% of the teaching staff can retire in the next three years (more than half of those staff are already has the time for retirement). Listed below are the Faculty recruitment priorities in descending order for Faculty (FAC), Agricultural Experimental Station (EEA) and Agricultural Extension Service (SEA) (Table 9.2.1)

Table 9.2.1 Faculty Recruitment Priorities

Ranking	Specialization	# of positions	Department	FAC/SEA/EEA
1	Agricultural Engineer	1	Biosystems and agricultural Engineering	FAC
2	Horticulturist	1	Agroenvironmental Science	FAC
3	Education in extension	1	Agricultural Education and Extension	SEA
4	Food Engineer	1	Food Science and Technology/ Agroenvironmental Science	EEA
5	Animal Nutritionist	1	Animal Science	FAC
6	Agricultural Economist	1	Agricultural Economy and Rural Sociology	FAC

10. LEARNING RESOURCES

10.1. Inventory of existing resources

Reports describing library resources (books, journals and electronic databases) are included in Appendices F and G. In addition, The Agricultural Experimental Station Library maintains, yearly, the subscription of the Access Digital Library Database of the

Alliance of Crop, Soil and Environmental Science Societies (https://dl.sciencesocieties.org) and provides access to 88 different databases at http://libguides.uprm.edu/az.php?s=96802.

10.2. Improvement plan

It will be necessary to review periodically the availability of books and scientific journals most relevant to agriculture. Cutting-edge research requires that our professors and graduate students have access to the principal references of their areas of specialization. During the first year of the program, $12,000 will be needed for the acquisition of technical journals and other publications. The amount budgeted for this purpose is expected to increase each year. Although the General Library of the University of Puerto Rico Mayagüez Campus, which has more than 1 million titles, provides direct support to the university community, library resources related to agriculture should be improved. The College of Agricultural Sciences has an Agricultural Library in the Research and Development Center at Río Piedras but this facility lacks space and is too far physically from the Faculty of Agriculture to be used frequently by professors and graduate students. Although conditions have improved considerably in recent years, more funds should be assigned to the General Library to purchase subscriptions to scientific journals and books.

10.3. Other Resources

Computerized systems of databases will be used to compensate for possible information gaps in the General Library related to agriculture. Some research projects in the College of Agricultural Sciences have made extensive use of the AGRICOLA database. A list of electronic databases available at UPR-M is included in Appendix J. It is expected that the doctoral program will strengthen research and increase the use of computerized library resources. Inter-library loans are also expected to increase. It should be noted that other resources, in addition to the Online Computer Library Center (OCLC) located in the General Library, include library resources available in the USDA and the resources of USDA Tropical Forestry Institute in Río Piedras. Also is available for graduate student and professor a new facility commonly known as GRIC (Graduate Research and

Innovation Center). GRIC is located at the General Library that is a creative and flexible space to foster collaboration and innovation for graduate students and professors (http://libguides.uprm.edu/gric).

11. PHYSICAL INFRASTRUCTURE AND EQUIPMENT

11.1. Inventory of available facilities

The College of Agricultural Sciences has on the Mayagüez Campus more than 50,000 ft^2 of space for classrooms, offices and laboratories. In addition, there are research farms and facilities available at the Agricultural Experiment Station (AES) Research Center in Río Piedras, the AES Substations in Gurabo, Corozal, Fortuna, Lajas, Adjuntas and Isabela, Montaña farm at Aguadilla, and Alzamora farm located at main campus. The UPR assign budget exclusively to AES for faculty, staff, utilities, etc. to support applied and basic research. USDA-NIFA provide capacity funds every year for research to solve local agricultural problems. Faculty continuously are increasing the search for external funds to pay for equipment, materials and graduate assistantships.

All these facilities have staff and administrators who are in charge of obtain permits from regulatory agencies of the government of Puerto Rico such as: use, firefighters, explosives, underground discharges, among others.

The location of the facility or laboratory is indicated within parenthesis if it is not located on the Mayagüez Campus at Mayagüez. The following is a list of laboratories and other research facilities available for the proposed doctoral program.

11.1.1. Animal Science Facilities

- Laboratory for milk products and technology, processing plant for fresh milk and other dairy products (UPRM)
- Dairy laboratory (UPRM)
- Veterinary physiology laboratory (UPRM)
- Animal nutrition laboratory (UPRM)
- Embryo transfer laboratory (UPRM)

- Laboratory for the artificial insemination of swine and poultry and incubation for avian eggs (Lajas)
- Dairy farm (Lajas)
- Animal Science laboratory (UPRM)
- Animal Molecular Biotechnology Laboratory (UPRM)
- Meat technology laboratory (UPRM)
- Beef cattle farm (Aguadilla)
- Small-ruminant animals farm (UPRM)
- Poultry rearing facilities (meat, eggs and quail) (Lajas)
-

11.1.2. Plant Science facilities

- Plant Science Laboratory (UPRM)
- Tissue culture and bioscience laboratory (UPRM)
- Plant and post-harvest physiology laboratory (UPRM)
- Fruit and organic agriculture laboratory (UPRM)
- Plant propagation laboratory (UPRM)
- Physiology and plant nutrition laboratory (UPRM)
- Chemical instrumentation laboratory (UPRM)
- Greenhouses (All six research stations, UPR-Rio Piedras)

11.1.3. Soil and Water Resources Management facilities

- Soil and Water Management Laboratory (UPRM)
- Soil Chemistry laboratory (Mayagüez and Río Piedras)
- Crop Nutrition laboratory (UPRM)
- Chemical Instrumentation laboratory (UPRM)
- General Soils laboratory (UPRM)
- Soil Microbiology laboratory (UPRM)
- Remote Sensing and Geographical Information System laboratory (UPRM)
- Water Quality laboratory (Mayagüez and Río Piedras)
- Soil Physics laboratory (Mayagüez and Río Piedras)

11.1.4. Plant Breeding facilities

- Plant Science Laboratory (UPRM)
- Molecular marker laboratory (UPRM)
- Field laboratory, grains and legumes (Isabela)
- Field laboratory, tropical row crops (Isabela)
- Field laboratory (Lajas)
- Certified Organic Farm laboratory (Gurabo)
- Greenhouses (All six research stations, UPR)

11.1.5. Crop Protection facilities

- Plant Disease Diagnostic Clinic - Juana Díaz and UPR-M
- Plant Pathology and Epidemiology- Isabela
- Plant Protection laboratory (UPRM)
- Plant Pathology laboratory (UPRM)
- Entomology laboratory (UPRM)
- Nematology laboratory (UPRM)
- Biodiversity and Microbiology laboratory (UPRM)
- Biological Control laboratory (UPRM)
- Phytopathology and Tissue Culture Laboratory (Rio Piedras)
- Tropical Nematology laboratory (UPRM)
- Plant Virology laboratory (Río Piedras)
- Museum of Entomology and Biodiversity (Río Piedras)
- Center of Excellence for Quarantine and Invasive Species
    - Certified Containment Facilities (over $1 million State of the Art laboratory and greenhouse facilities inaugurated in 2014 in AES, Río Piedras; sponsored by USDA-APHIS-PPQ).
- Pesticide Research Center - Corozal
- Research Apiaries (Juana Diaz, Isabela, Gurabo, Lajas, Corozal, Adjuntas)

11.1.6. Other facilities available

- Agricultural Biometry laboratory (UPRM)
- Computer laboratory for agricultural economics and agribusiness (UPRM)
- Food Science and Technology laboratory (UPRM)
- Food Safety Institute (UPRM)
- Experimental kitchen for new products (UPRM)
- Central Analytical Laboratory (Río Piedras)
- Experimental areas at the Río Piedras Research Center, the Gurabo, Corozal, Juana Díaz, Lajas, Adjuntas and Isabela Substations and on the Alzamora Farm (Mayagüez) and Montaña Farm (Aguadilla).

11.1.7. Computer network

The computer network provides a series of essential services for academic, research and teaching activities that result in greater productivity. A few of the services available on the network are wireless connections, transfer of data, access to databases, printing resources, electronic mail and access to the Internet. Videoconference Lab and SmartBoard.

11.2. Impact of the program on the existing facilities

It is expected that the new program can operate using the existing infrastructure in the College of Agricultural Sciences. As the doctoral program develops, improvements and expansion of facilities and resources will be required.

11.3. Needs and availability of computer services for the new program

Given the options that will be initially offered and the limited number of students to be admitted in the first years of the program, it is not expected that the new program will have

a negative impact on the availability of existing computer services in the College of Agricultural Sciences. The existing communication infrastructure in the Faculty of Agricultural Sciences and Alzamora Farm will allow doctoral students to have access to the Internet at any time or place on the Mayagüez Campus using wireless technology. The hours of service of the different Computer Laboratories of the Faculty should be increased to allow printing and scanning and to provide more assistance concerning the use of different programs such as SAS, Infostat, Office and the Internet.

11.4. Other facilities, equipment, and services

Facilities available to the Program will continue to be developed and modernized. A recently inaugurated research facility will provide laboratory (4) and office space for doctoral students. In addition, offices for the administrative component of the Program will be refurbished. The university provides a series of services at no cost for all students. Among these services can be highlighted: medical, psychological and counseling services, recreation area and exercises, cafeteria, immigration (some charges may occur by federal agencies), bookstore, vehicles, among others. Department has clerical staff, and Directors during business hours able to help students in enrollment and other academic needs (Undergraduate catalog 2018-2019 https://www.uprm.edu/cms/index.php?a=file&fid=18862).

11.5. Financial support

Mentoring professors are encouraged to submit research proposals to partially support students needs. However, students are expected to have enough resources to successfully support their studies.

12. CATALOG AND DISSEMINATION OF THE PROGRAM

Ph.D. in Tropical Agriculture

The Ph.D. Program in Tropical Agriculture prepare new cohorts of highly skilled and ethical professionals at the doctoral level, trained to excel mainly, but not exclusively, in their work in tropical conditions, experts and leaders in their fields, capable of solving existing problems and generating new information and technology to expand basic and applicable knowledge related to agriculture, natural resources, and food science and technology. These new generations of thinkers, problem-solvers and innovators in the agricultural sciences should have a tremendous impact in the body of practical and basic knowledge as well as in the advancement of solutions for critical issues in food production and conservation of natural resources to sustain growing populations, situations that plague both in Puerto Rico and the rest of the planet.

Admission Requirements: BS in Agricultural Sciences or similar discipline. It is generally desirable that before enrolling in the doctoral program, the student earns a master's degree from an accredited University in Sciences or its equivalent with a major in Agriculture, Environmental Sciences, General Science, Chemistry or Biology. A minimum GPA of 3.25 is required for Science courses under the aforementioned disciplines, and GPA of 3.00 in other discipline courses. The applicant must have at least 9 credits in Agricultural Sciences related courses such as courses code in General Agriculture, Animal Sciences, Agronomy, Soil Sciences, Plant Science, Horticulture and Crop Protection. In addition, applicants must have at least 3 credits in Biostatistics or equivalent courses. Students will be accepted with a maximum of 4 courses on deficiencies and will be encourage to fulfill deficiencies requirements through professional development.

Applicants will be required to take the general Graduate Record Exam (GRE) and the Examen de Admisión a Estudios de Posgrado (EXADEP) taken within three years prior application to graduate school. The scores from verbal and quantitative portions of the exam will be considered. The applicant must submit a 2-page CV along with a short essay (max. 1,000 words) indicating short and long term goals. The essay must include applicant's research experience, interests and potential contribution of research goals to

foster Tropical Agriculture. It is expected that the applicant has adequate spanish and english language proficiency in both oral and written forms.

The Doctor of Philosophy degree will require the completion of a minimum of 57 credits (100%) distributed as follows:

- 20 credits (35 %) for seven core courses
- 15 credits (26 %) for the doctoral research and thesis
- 1 credit (2 %) for the doctoral seminar
- A minimum of 21 credits (37 %) in recommended elective courses.

The description of the program, which was outlined in section 6.1, and the descriptions of the courses, which were outlined in section 6.2, will be included in the Graduate Studies catalog of the University of Puerto Rico Mayagüez Campus. Once the proposed program is approved, a promotional bulletin will be prepared and disseminated to contacts in universities in Puerto Rico, the Caribbean, Latin America, the United States and other countries. The doctoral program will also be promoted through the Internet sites of the University of Puerto Rico, the University of Puerto Rico Mayagüez Campus, the College of Agricultural Sciences, the Agricultural Experiment Station, the Agricultural Education and Extension Service, and the Office of International Programs of the CAS.

13. ACCREDITATION AND LICENSING OF THE PROGRAM

13.1. Professional accreditation

The proposed program will be evaluated according to Certification JS 43 (2006-2007) of the University of Puerto Rico. Practice is not required for this program.

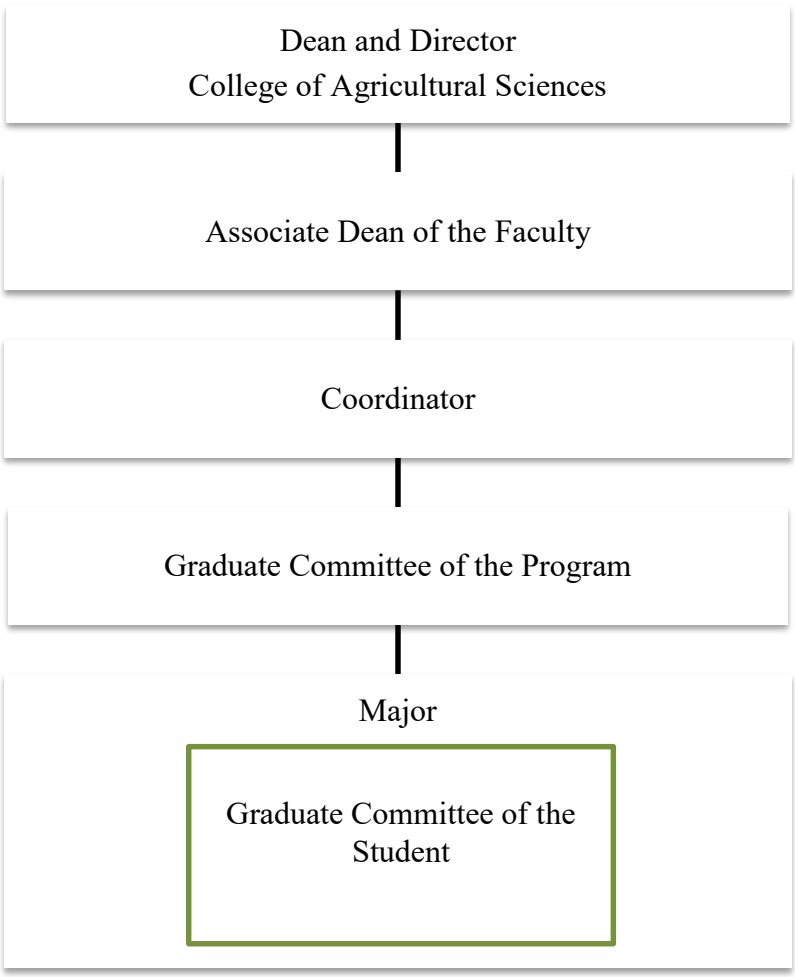
13.2. Licensing by the Council of Higher Education

After the responsible entities within the University of Puerto Rico have approved the proposed Doctoral Program, the Council of Education of Puerto Rico will review and decide upon approval of the program.

13.3. Administration of the Program

The administrative organization of the program is presented in Figure 13.3.1. The following paragraphs will describe functions and composition of the different components of this administrative structure.

Figure 13.3.1 Administrative Organization of the Doctoral Program in Tropical Agriculture.



Coordinator – This person will be in charge of the administration of the program. The following are his/her responsibilities:

- Preside over the Graduate Committee and membership of the UPRM Graduate Council.
- Coordinate the offering of the courses of the program in collaboration with Department Directors.
- Coordinate and promote students enrollment into the program.
- Coordinate the participation of professors of other colleges and campuses in the program.
- Process student's applications for admission or transfer into the program.
- Advise students concerning academic affairs, research and economic assistance.
- Learn about new initiatives in agricultural sciences within and outside of Puerto Rico.
- Maintain an active relation with the private sector, the government and other universities in Puerto Rico that contribute to the accomplishment of program objectives.
- Supervise the development of the program and generate an annual report describing the achievements of the program.
- Maintain a continuing process of evaluation of the program.

The Coordinator will be appointed by the Dean and Director of the College of Agricultural Science, in consultation with the Graduate Committee of the Doctoral Program, and will be under the direction of the Associate Faculty Dean of the College of Agricultural Science. The position of Coordinator will have an administrative load and a salary differential equivalent to a department director. The Coordinator will have the assistance of the administrative personnel of the College to carry out his/her responsibilities.

Graduate Committee of the Doctoral Program – This committee will include the Coordinator of the program, one professor representing each academic department of the College of Agricultural Sciences and a representative of the Food Science and Technology

program. All committee members will be selected by their peers for a three years appointment. The committee will have the following responsibilities:

- Review and approve the general admission requirements for the program.
- Review and submit for approval the recommended core and elective courses.
- Evaluate and make recommendations regarding requests for admission to the program.
- Establish the specific requirements for transfer between to the program.
- Evaluate and approve the incorporation of new courses.
- Evaluate and make recommendations concerning new topics for the program.
- Prepare and administer, in collaboration with the student's graduate committee of the student, the qualifying exam and other exams required for the degree.
- Learn about new initiatives in Agricultural Sciences.
- Maintain an active relationship with the private sector, the government and other universities in Puerto Rico that contribute to the accomplishment of the objectives of the program.
- Supervise the development and sustainability of the program and other pertinent reports.

This Committee will evaluate courses that must be previously approved by the faculty, following existing regulations. All members of this Committee must have an academic rank of at least Associate Professor or equivalent and be active in research as evidenced by scientific publications.

Graduate Committee of the Student – The committee will be responsible for preparing the student's program, supervising his/her research and dissertation preparation. The committee will also be responsible for determining whether the student has passed the Candidate Exam. The members of this Committee should be selected by the student with the approval of the Graduate Committee of the Doctoral Program following graduate studies of the University of Puerto Rico, Mayagüez Campus regulations

President of the Graduate Committee – The president of the Graduate Committee of the student will be responsible for recommending the course work and supervising the research needed to obtain a doctoral degree. The president of the committee will have a minimum academic rank of Associate Professor (or equivalent), and be active in research as evidenced by scientific publications.

Students – The students will be admitted to the program.

Administrative and other support personnel – The administrative staff of each department in coordination with the staff of the finance office, the register office, immigration office, medical services, along with others would be in charge of assisting students admitted to the doctoral program. Each department and/or research stations will provide research and teaching assistants.

14. ECONOMIC ASSISTANCE FOR STUDENTS

Each year, some of the graduate students in the College of Agricultural Sciences receive assistantships, which are for teaching or research. Teaching assistantships are supported by the general fund of the University of Puerto Rico whereas research assistantships are mostly supported by external funds. Among the 158 graduate students enrolled in the College of Agricultural Sciences during the second semester of the 2013-2014 academic year, 109 received teaching assistantships and 43 were awarded research assistantships. For academic year 2014-2015, the Agricultural Experiment Station and Cooperative Extension Service will sponsor 38 research assistantships each per semester (Total of $140,000) in addition to those sponsored with external funds.

The establishment of a new doctoral program in Tropical Agriculture will serve as a vehicle to increase research activities in the College of Agricultural Sciences. It is expected that this increase in research will result in an increase in external funding and an increase in the number of research assistantships for graduate students. In addition, each president of a graduate committee will be responsible for generating the external resources needed to conduct the dissertation research. Funds will be included in the budget to cover expenses

for exceptional cases, when the student, by no fault of his/her own, is deprived of funds for a research assistantship.

15. BUDGET

To offer a program of excellence, it will be necessary to obtain additional funds. The additional costs of offering the program are described in Table 15.1.

15.1. Recurrent costs

Additional academic loads for teaching the doctoral courses and for the direction of dissertation research must be considered in order to offer the doctoral program. Table 15.1 indicates that an additional 18 credits per semester will be needed during the first five years of the program. These credits will be distributed according to the needs of the doctoral program. No more than two contingency assistantships will be included in the budget. Funds will also be used for the administrative costs of an External Advisory Committee of the Program. This Committee will be composed of members of the private sector, representatives of Federal and Puerto Rican agencies, other citizens and members of the academic community. The Committee will meet every five years to review the implantation and development of the doctoral program and submit recommendations to the Coordinator of the Program and to the Dean and Director of the College of Agricultural Sciences. The budget also includes funds for the General Library to procure new library resources and for the purchase of equipment and property (laboratory and farm equipment, animals, farm vehicles and computers) to be used primarily by the participants of the program.

As indicated in Section 13, the Coordinator of the Program will have an administrative load and a salary supplement equivalent to that of a department director. At present, the monthly supplement for a department director is $910.00 on the University of Puerto Rico Mayagüez Campus. The administrative and computer support personnel of the office of the Associate Dean of the Faculty of Agricultural Sciences will provide administrative and secretarial assistance needed for the proposed program.

Table 15. 1. Budget of the proposed doctoral program

Item	First year	Second year	Third year	Fourth year	Fifth year
Recurrent costs					
Additional academic load (36 credits/year)	97,900	97,900	97,900	97,900	97,900
Research assistantships (2 @ $13,800)	27,600	27,600	27,600	27,600	27,600
Library resources	12,000	12,800	13,700	14,600	15,600
Administrative personnel					
Coordinator (compensation)	10,920	10,920	10,920	10,920	10,920
Secretary	6,600	7,000	7,400	7,800	8,200
Office materials	6,000	7,000	7,000	7,000	8,350
Maintenance and repair of equipment		25,000	45,000	65,000	95,000
Total recurrent costs	$161,020	$188,220	$209,520	$230,820	$263,570
Non-recurrent costs					
Equipment		225,000	215,000	215,000	215,000
External Advisory Committee					12,000
Total non-recurrent costs	0	$225,000	$215,000	$215,000	$227,000
Total costs	$161,158	$413,358	$424,658	$445,958	$490,708

15.2. Non-recurrent costs

The proposed doctoral program will require the complete renovation office space for the administration of the Program. There is space available on the Alzamora Farm of the University of Puerto Rico Mayagüez Campus, adjacent to the recently inaugurated research laboratories to build these facilities. In addition, funds to purchase equipment and funds to support an external advisory committee for the program have been included in the budget. Some equipment has been bought with external funds.

15.3. Income

At present, it is not possible to estimate the amount of external funds that will be available for the doctoral program. It is anticipated, however, that the external funds generated by eligible faculty and other participants in the program should be sufficient to provide at least partial support for the program. Among the integrated departments more than $5,000,000 is awarded annually for research programs in the different areas of

Agricultural Sciences. Federal and state funds, donations and external fund provide support for graduate assistantships, equipment, materials, administrative personnel and indirect costs.

16. EVALUATION

The evaluation of the Doctoral Program will be the responsibility of the Program Coordinator in coordination with the Graduate Program Committee. The process of evaluation will be ongoing and will use quantitative and qualitative parameters to determine the effectiveness and efficiency of the program in complying with the goals and objectives and forming professionals with the expected profiles. The information compiled during this process will be analyzed to determine whether there are changes needed to strengthen the program in the administration, budget, teaching, and admission requirements. There will be an annual evaluation. At the end of the academic year a report such as the following table will be rendered as an indicator of the program's success (Table 16.1).

Table 16. 1. Evaluation measures and indicators of success for the Doctoral program

Evaluation	Measure	Success Indicators
	General Point Average (GPA) GRE Score	80% of students admitted with undergraduate GPA ≥ 3.25 and ≥ 3.25 in STEM. 80% with graduate GPA ≥ 3.50 80% of students with GRE scores ≥ 300 math and verbal parts combined.
2. Performance and retention of students in the Program	Student portfolio ● Transcript of credits (completed courses, GPA) ● Seminars ● Qualifying Exam ● Candidate Exam ● Thesis Exam	90% of students with GPA ≥ 3.00 80% of students pass exams at first attempt

Evaluation	Measure	Success Indicators
		80% student progress according to the time frame of the curriculum sequence 80% students accepted complete the degree in 3 to 5 years 80% of students in each cohort complete the degree
3. Financial Aid	Student portfolio ● Teaching Assistants ● Research/lab assistants ● Scholarships	All students will teach at least one course and will do research as an assistant. At least one student in each group will have a fellowship.
4. Excellent projection of students in local and international scientific forum	Student portfolio ● Oral presentations in scientific meetings ● Abstracts at scientific meeting ● Poster presentations ● Referred articles published	Each student along with his/her thesis advisor will give at least two oral presentations, two poster presentations and will publish at least one manuscript in a professional journal.
5. Generation of external funds	Student portfolio ● Grant proposals submitted ● Increase in external funds	20% of students with his/her thesis directors will submit at least one grant proposal for external funds. 20% of the proposals submitted will be subsidized. During the first five years of the program, external funds will increase by 20%. Program Coordinator
6. Student satisfaction with the program	Annual questionnaire to students about counseling, courses, curriculum, physical plant, program administration, professional competence, quality of research	80% of the students are satisfied with the program and recommend it to others. Annually. Program Coordinator

Evaluation	Measure	Success Indicators
7. Success of graduates in obtaining employment	Questionnaire to graduates one, three, and five years after completion of Ph.D. degree	Three years after completing the degree, 80% of the graduates are working in areas related to the program. Program Coordinator
8. Graduate's satisfaction with the program	Questionnaire to graduates regarding counseling, courses, curriculum, physical plant, program administration competence.	One to three years after completing the degree, 80% of the graduates are satisfied with the program and recommend it to others. Program Coordinator
9. Satisfaction of employers with graduates	Questionnaire to employers one, three and five years after first class graduation. Evaluation of satisfaction with leadership, research and analysis capacity, ability to write and publish results, ability to develop and apply new technologies, oral communication skills, and competence in the area of specialty, value for the business, agency or university.	80% of the employers interviewed indicate satisfaction with the quality of the graduates and will have other graduates of the program. Program Coordinator

17. DEVELOPMENT PLAN

Objectives

To increase the offer of graduate studies in general, and doctoral studies in particular, in the University of Puerto Rico System.

To establish a doctoral program in agricultural sciences in a Spanish-speaking location within the US educational system, an appealing prospect for international students from Latin America.

To promote multidisciplinary academic research.

To train students to apply the scientific method to solve problems and develop new knowledge in tropical agriculture.

To expose students to new knowledge and techniques in agricultural sciences, with emphasis in tropical species and environments.

To educate students to be critical thinkers and innovators in regards to tropical agriculture systems and problems.

To train students in skills that allow them to work individually as well as in collaboration, as necessary.

To strengthen in students a culture of professional ethics.

To instill in students a culture and consciousness of respect for proper and sustainable use of natural resources for agricultural purposes.

To prepare new generations of professionals at the highest academic level with the skills and tools to be leaders, innovator, problem-solvers and enhancers of the standards of agricultural production and natural resources use and conservation, positively impacting society and science in Puerto Rico and/or the countries where they work.

To establish and develop relationships with organizations in agricultural sciences, locally and globally, that may fortify and facilitate the training of the students and the development of the Program.

Student Program Registration and appraisal activities

In the first year are expected 1-2 student per semester for the program and the remaining years 3 students per program. The activities necessary to begin the process of accreditation of the program will be curriculum evaluation; and five-year evaluations the activities of the student learning outcomes assessment and academic appraisal activities. There is no accrediting agency for the program, which initially used the Middle State

The most significant challenges that will have as well as the obstacles;

Challenges:

- To promote the only doctoral program in agricultural sciences in the Caribbean and Puerto Rico
- Maintain the current staffing of teachers and hire new resources
- To get more external funds to cover the costs of barriers
- To coordinate the use of facilities outside the Mayagüez Campus
- The Administration should create mechanisms to increase local and external funds of donors in support of the doctoral program.
- Strengthen graduate education (masters and PhD)

- Establish mechanisms so that students in the program to complete their requirements for graduation according to the term.

Obstacles:

- Financial situation of the University
- Have funds to provide student assistantships
- Maintain budget for the maintenance of the facilities
- The criteria to be used to establish priorities and allocate resources;
- Establish research to meet the needs according to the State Agricultural Department and USDA.
- Expected graduation rate; 75%
- The expected strengthening of library resources; In 5 years we hope to have a good source of information in the general library and you will carry out the study to establish a small library in the Piñero building for students in the doctoral program.
- New courses to be created
- Titles of research in progress and which are projected to begin as well as its relevance to the social reality and the economic development in Puerto Rico and the Caribbean; It will establish research to meet the needs according to the Department of agriculture and USDA.

The recruitment, development and evaluation of faculty

The Recruitment Plan of the College of Agricultural Sciences calls for, within the next two years, the hiring of the following academic personnel with doctorate degrees: in the Animal Science Department, a Reproduction Physiologist in poultry science and a Veterinarian and in the Department of Agro-environmental Sciences, a specialist in Natural Resources, a Plant Pathologist; in the Program of Food Science and Technology a Nutritionist. Another strategy would include Faculty with a doctorate degrees from the University of Puerto Rico at Utuado. These professors have is: Entomology, Plant Physiology, Agroecology and Animal Physiology and Reproduction. Other various campus resources can help you strengthen the program. The evaluation of the teacher, according to the certification of the Board of management of the University of Puerto Rico will be used.

The strengthening of the program will begin with courses and certification of teachers in preparation and creation of online courses. Doing training strategy. Integration into the curriculum of the use of information systems will be held with the creation of courses online or hybrid in Moodle. The periodic evaluation of the program will be made with the 5 year period

Assessment of learning:

What should students learn?

The students learn with purpose and on a continuous basis. Demonstrate creative thinking to create new ideas and different solutions. Communicates effectively, Identify, study and apply solutions to problems; transforms knowledge into action. Uses of mathematics, technological skills and integration and interpretive skills. It relates to matters of importance to PR and global contexts. The students will show moral autonomy, possesses a sense of human well-being and meet the ethical conduct.

How well students are learning and how do we know?

The students will show that are learning through the research, examinations, projects and academic progress. Will be known that the students are learning when efficiently and effectively complete the requirements of its research, courses and graduate Committee.

How can improve the teaching and learning?

To improve the teaching and the learning of the students, will should Receive the input of students during the process of evaluation of the research and the appraisal of all graduate courses. The preliminary evaluation will be after the first year, and then it will be annual until the fifth year. After the first student graduate, the evaluation of the program progress will be every two years.