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PROCEEDINGS

OF THE

38th ANNUAL MEETING

June 30th – July 5th 2002
Hôtel Méridien, Trois-Ilets, Martinique

**“Quel devenir pour l’agriculture caribéenne ?
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Published by:

AMADEPA
Ex Hotel de ville, Rue Schoelcher,
97 232 Lamentin, Martinique
E-mail : amadepa@wanadoo.fr
Phone : 596 76 62 36
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GLOBAL TRADE AND TECHNOLOGICAL CHANGE IN ROOTS AND TUBERS: THE CASE OF PUERTO RICO*

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RESUME

Les racines et tubercules ont été jusqu'à présent un composant majeur dans l'alimentation locale sous les tropiques. Leur production sert surtout à la consommation des ménages et aux marchés locaux, une partie relativement faible étant réservée à l'exportation. Malgré le déclin de l'agriculture de longue date, l'autosuffisance dans la plupart des racines et tubercules fut la norme à Puerto Rico jusqu'au début des années 80. Depuis lors, la production a baissé considérablement à mesure que les importations de certaines de ces productions qui sont l'objet d'expérimentations augmentent. La présente communication explore l'interface entre les procédés globaux et les conditions locales, et le rôle que le changement technologique (ou le manque de changement) peut avoir joué dans la configuration du statut courant des racines et de la production de tubercules à Puerto Rico. Méthodologiquement le débat est mené par examen local et global de la production et des statistiques du commerce depuis 1964, et à un second degré des sources provenant du développement du marché agricole portoricain, de la littérature technologique disponible au niveau local et international sur les racines et les tubercules. Les résultats préliminaires dénotent que des changements dans le commerce global et local des productions alimentaires, ont été davantage responsables de la situation courante de la production de racines et de tubercules de Puerto Rico que dans les changements technologiques.

ABSTRACT

Roots and Tubers have been until recently a major component of local diets in the Tropics. Their production has been mostly for household consumption and local markets, exporting only a relatively small proportion of produce. In spite of a long term agricultural decline, self-sufficiency in roots and tubers was the norm in Puerto Rico until the early 1980s. From then onwards, production declined significantly as imports experienced more than concomitant increases. This paper by examining global and local production and trade statistics since 1964, local agricultural and marketing developments, and the available technological literature on roots and tubers explores the interface between global processes and local conditions. Preliminary results suggest that changes in the global and local marketing of food crops have been more responsible for the current status of roots and tubers production in Puerto Rico than technological change.

* This paper is a contribution to USDA-CSREES southern regional project S-276 "Rural Restructuring: Causes and Consequences of Globalized Natural Resource Systems".

INTRODUCTION

Roots and tubers (R&T) have been for centuries a staple food in many developing countries, particularly in the Tropics. Nevertheless, while the world per capita availability of fruits and vegetables increased 66.7 per cent from 1961 to 1998, and that of meat and cereals, 60.8 per cent and 16.9 per cent respectively, the global per capita availability of roots and tubers declined 21.6 per cent (Economic Research Service/USDA, 2001: 13). In spite of this overall declining trend, in the Caribbean region, with variations from island to island and among the bigger countries, R&T have remained until relatively recent times an important component of local diets and in most cases, of commercial agriculture.

Traditionally produced for household consumption and local markets, only very small quantities of the major R&T were traded internationally before the 1970's. Generalizations are difficult to make since export trends are highly variable and each individual crop follows a different pattern. Nonetheless, crops such as potato (*Solanum spp.*), yam (*Dioscorea spp.*), cassava (*Manihot esculenta*), sweetpotato (*Ipomoea batatas*), and taro or malanga (*Colocasia esculenta*), show although with wide fluctuations an overall trend towards increasing exports, particularly after the mid 1980s (FAO, 2002b).

In Puerto Rico, as in many developing countries, roots and tubers¹ were an important component of the local diet at least until the mid 1970s. Department of Agriculture statistics from 1950 to 1999 show that until 1964 local consumption paralleled local production trends, rising from 1950 to 1954, and then declining sharply until 1964. Still, until 1969 local production exceeded local consumption by a small margin and, as was the case for yam and yautia (*Xanthosoma saggitifolium*), some of it was exported. From then onwards, both trends began to diverge, as production continued to decline while consumption and imports increased significantly. After 1987, both consumption and production declined sharply while imports continued to increase. Only recently production seems to have stabilized somewhat, while consumption rose sharply, provoking, or stimulated by, an equally marked increase in the level of imports.

The initial question guiding this study dealt with assessing the role that global and local technological change (or lack of) had played in determining the present outlook of roots and tubers production in Puerto Rico. Technology has been hypothesized as playing an important role in spurring globalization trends. Through the transfer of internationalized technological packages to different localities, the establishment of global cool chains, and a changed organization of production and distribution, trade in certain crops have increased tremendously in the last decades (Friedland, 1994a). Fresh fruits and vegetables have been the commodities which better exemplify the changes that globalization brought about in the prevailing patterns of production, consumption, trade and local distribution, both in developed and developing economies (Epperson and Estes 1999; Friedland, 1994b; Goldfrank, 1994).

Roots and Tubers, considered by some countries experiencing expanded production and trade in fresh fruits and vegetables as part of their "non-traditional agricultural exports", deserve nevertheless a separate analysis. While there is evidence of an increase in the production and trade of selected R&T in certain countries, their growth is less impressive than the one experienced by fruits and vegetables in general, and subject to greater fluctuations (Thrupp, Bergeron, and Waters, 1995). Yet, at least in the Americas, expanded trade appears to be linked to these crops' incorporation into the new global fresh fruit and

¹ Unless otherwise specified the roots and tubers included in the Puerto Rican case analysis are yam, taniér or yautia (*Xanthosomasagittifolium*), sweetpotato, cassava, taro or malanga, and arracacha or apio (*Arracacia xanthorrhizai*)

vegetable commodity system which combines into a “commodity chain”, processes of production, processing, packaging, exporting and consumptive activities (Raynolds, 1994a). In this context, it is relevant to explore if the observed changes in the production and trade of roots and tubers are more related to the restructuring of trade and marketing brought about by the globalization process, than to any transformation of production conditions due to the adoption of technological innovations. The examination of these propositions in the case of Puerto Rico is the subject of this study.

METHODS

Global statistics on production, consumption, imports and exports of roots and tubers from 1964 to 1999 were consulted using the Food and Agriculture Organization (FAO) database collections in the internet, particularly their Food Balance Sheets. Puerto Rican statistics on the same variables and years were obtained from the local Department of Agriculture, Office of Agricultural Statistics. Information from both sources was graphed or tabled to facilitate comparisons.

Two types of sources were employed for the review of the literature on technical change in roots and tubers. First, all of the indexed articles published in the University of Puerto Rico’s Journal of Agriculture (JAUPR) one of the oldest and principal journals on tropical agriculture in the Americas on these crops since its inception in 1917 until 1999, were identified and organized into a computerized database, that could be sorted by crop, author, title, principal discipline of work and year of publication. For analytical purposes the literature review covered four periods: (1) research published before 1950, (2) articles published between 1950 and 1969, (3) publications made from 1970 until 1989, and (4) research published after 1990. A general content analysis of this literature was performed by reading all titles and, when in doubt about the content of the article, the abstract of the publication. Citations were then tallied by crop, year and major topic area. Second, a partial review of other types of publications on roots and tubers available in the University of Puerto Rico Agricultural Experiment Station (AEXS) Library and in the Internet, was also performed to gain a sense of the research carried elsewhere during the time periods studied.

Lastly, the assessment of possible interrelationships between broader global processes, local conditions, and technological change was accomplished by examining part of the growing literature on the globalization of agriculture and food, and selected studies, statistics, and government publications on Puerto Rico’s agricultural and marketing developments in the twentieth century.

TRENDS IN PRODUCTION, CONSUMPTION, IMPORTS AND EXPORTS OF SELECTED ROOTS AND TUBERS FROM 1964 TO 1999: GLOBAL AND LOCAL ASSESSMENT

Global Trends

Figure 2 shows graphically the aggregated trends in production, consumption and export of roots and tubers for selected years from 1964 to 1999, according to the FAO (2002a) Food Balance Sheets. In general, the data show overall increases in the three variables, although production and consumption increases were more significant than the growth in exports, according to this source.

Table 1 presents in more detail the import and export picture for roots and tubers in 1964 and 1999 derived from the FAO (2002b) Agriculture and Food Trade databases. Several trends are evident from the examination of these trade statistics. First, most roots and tubers experienced tremendous trade increases after 1964. With the exception of cassava, which allegedly “is not traded internationally in its fresh state because tubers deteriorate very rapidly”² (FAO, 2002c), and potato which has a long international trade history all the other crops experienced export increases of more than 150 per cent from 1964 to 1974. In the next two decades this overall pattern of export growth continued for most roots and tubers. Yet, a second trend evident in these data is the wide fluctuations to which imports and exports of roots and tubers are subject to. From 1994 to 1999 exports and imports declined around 89 per cent for sweet potato; from 1984 to 1999 *yautia* exports declined 37 per cent and imports 100 per cent. While there may be deficiencies in the data collection and reporting of these crops, and variability due to changing climatic and production conditions, fluctuations certainly also reflect the changing trade environment that the globalization of food and agriculture has introduced world wide.

Local Trends

In general, except for production trends, Puerto Rico followed the global pattern of increase in roots and tubers consumption and imports, and of decline in the per capita consumption of these crops. Production, in contrast to the world pattern, experienced a sustained decline, a trend evident since 1954. However, the pace of this decline was highly uneven among the different crops and among decades, as can be observed in Table 2. The total consumption of roots and tubers rose sharply, particularly after the 1974 extension to Puerto Rico of the US federal Food Stamp Program (FSP). Imports began to fill the gap left by the continuous production declines sustained by these crops. In 1964 R&T imports were almost negligible, amounting to less than 1 per cent of total consumption. By 1984, when total consumption peaked, imports amounted to 41 per cent of the aggregated consumption for all crops. In 1999 this proportion had hiked to 80 per cent, as imports increased and total consumption declined 8 per cent (Table 2).

CHANGES IN ROOTS AND TUBERS PUBLICATION PATTERNS, AGRICULTURAL STRUCTURE AND FOOD MARKETING IN PUERTO RICO: 1920S TO 1999

In the JAUPR between 1920 and 1999, a number of articles on roots and tubers divide the publication trend into four distinct periods. *Period I (1920s-1949)* covers the years when sugar, coffee and tobacco were still at the fulcrum of Puerto Rico’s economy and very little research on roots and tubers was published. As Table 3 shows, only 2 per cent of the R&T publications in the JAUPR were produced before 1950. *Period II (1950-1969)* is characterized by the emergence of production technology research and post-harvest studies (Table 4), and by the rapid transformation of Puerto Rico from an agricultural to an industrial economy. 16 per cent of the total publications on roots and tubers in the database were made during this period (Table 3). Not only was the island’s agricultural structure modified during these years³, but both food consumption habits and food marketing underwent important changes that eventually affected the future prospects of R&T in Puerto Rico. Paramount among these was the introduction of “supermarkets” to the

2 Perhaps trade in fresh cassava is still negligible for FAO statistical respects, but beginning in the 1980s with the application of waxing techniques to the preservation of fresh tubers, fresh cassava began to be marketed broadly in Latin America and the Caribbean. See Reynolds (1994b) for an account of these “non-traditional exports” growth in the Dominican Republic during the 1980s.

3 Census of Agriculture data since 1949 show the breakdown of sugar and tobacco production, and the fluctuating but overall decline in the numbers, land and production of the most important food crops, particularly evident in the case of R&T since 1978 (U.S. Census Bureau 1987; USDA-NASS 1998; Weisskoff 1985).

island in 1955. However, only the bigger, commercial producers of food crops were able to accommodate the quality and packaging requirements of the big supermarket chains. Most R&T producers had to continue selling their crops to truckers visiting their farms, which in turn were in charge of transporting the produce to urban wholesalers or to the traditional smaller stores (Carro-Figueroa, 2000).

The third period (1970-1989) includes the years when most of the research carried out on these crops was published. Sixty-five per cent of the total number of JAUPR publications on R&T was made during this period (Table 3). Production technologies and post-harvest research and development (R&D) still dominated the publications' profile, but the disciplinary emphasis shifted from the cultural practices, entomological, and plant pathology studies of the previous period in the production side to an emphasis in soil, fertilizers, herbicides and other chemical inputs research (Table 4). Post-harvest R&D, on the other hand, shifted from studies mostly related to the canning characteristics of sweet potatoes, to a broad spectrum of studies on the processing potential of roots and tubers. Encompassing the years of the final breakdown of the sugar plantation economy, of the extension to Puerto Rico of the U.S. federal Food Stamp Program (FSP), and of the implementation of a new government policy for the modernization of agriculture; this period also witnessed the publication of the first technological package for the production of roots and tubers, summarizing the field research knowledge accumulated over the years on these crops. In marketing terms, supermarkets were able to consolidate their predominance in the local economy, since they were in a better position to supply the wider variety of products demanded by the new purchasing power consumers had acquired with food stamps. Seasonal variations in local supply, coupled with increased availability of root crops in world markets at competitive prices, inclined suppliers of large supermarkets to increase the imports of roots and tubers, frequently bypassing local channels altogether. The trade agreements and market liberalization policies implemented since the 1980s have further facilitated this process in subsequent years.

The fourth period (1990-1999) a decade shorter than the previous ones is characterized by a sharp decline in the number of publications made in the JAUPR, mirroring the trends in the production and consumption of roots and tubers, while imports continued with their steep rising pattern. Thirty-two per cent of total publications correspond to this period (Table 3). Research continued to be mainly focused in production technology, but studies related to the plant's manipulation (physiology, breeding) became more prominent in the publication outlook. Post-harvest R&D, however, was minimal. Part of the explanation for the reduction in publications on these crops resides in the declining research staff of the local AEXS. The number of scientists working in the AEXS during this period reached its lowest point since 1949. In terms of policy, during this period the government opted for a "new" economic development model based on the retirement of the state from many of its former functions, and gradual privatization of its assets and direct operations. In this new model the role of agriculture in the island's economy was largely ignored, as investment in the sector was severely curtailed, and a reorganization of all farm service agencies and public credit institutions was adopted. Both the budget of the local Department of Agriculture and of the University's research and extension agencies were affected. This critical situation comes at a time when it is generally recognized that changing diets, natural disasters, trade and market liberalization, and the protection of natural resources will all affect the future demand and supply of roots and tubers globally. To be able to face these challenges new technology to increase sustainable production, stimulate new uses, and new ways to consume these crops must be devised (Scott, Best, Rosegrant and Bokanga, 2000).

DISCUSSION AND CONCLUSIONS

This paper explores the relative importance of the technological variable in the complex processes grouped under “globalization” as an analytical category, taking the case of roots and tubers in Puerto Rico as an example. The examination of the data and literature on changes in the global production and trade in roots and tubers suggest that, while there has been an expansion in both variables, trends are subject to wide fluctuations and variability among the different crops. While in some countries productivity has increased from the adoption of production technology, in others, expanded production has been an outcome of an increase in the area cultivated (Scott *et al.*, 2000). The growth in trade appears to have been facilitated by the combined adoption of post-harvest technologies which prolong the shelf-life of these crops with processing and packaging for export incorporating R&T into the more stable global fruit and vegetable commodity chain (Raynolds, 1994a).

One of the conclusions that emerge from the analysis of the JAUPR publications profile is that even though it is generally acknowledged that research on R&T was largely neglected by national and international institutions before the late 1960s, Puerto Rico conducted important production and processing technology research on these crops at least since the 1950s, but it was never significantly commercialized. The risks involved in the marketing of these crops even before expanded global trade and changes in the food distribution system associated to globalization had taken place limited the adoption of technology by the small farmers of the island which dominated the sector’s productive structure. The combination of high input prices and stagnant or declining prices for their produce made technology adoption a risky proposition for Puerto Rican R&T farmers, a condition which was exacerbated during the 1980s.

Irrespective of the increase in the number of local publications, other research centers worldwide were able to take the lead, and other countries and private entrepreneurs were able to capitalize on existing and new post-harvest technologies to improve the marketing potential of these crops. For example, experiments conducted in Colombia by Buckle and colleagues (1973) with the waxing of cassava showed that it could extend the storage life of the crop from 2 to 3 days up to about 30 days, by preventing discoloration in the vascular tissue (FAO 1981). The successful application of this technique to cassava commercialization made possible the expansion in the regional trade of the crop in Latin America, amply evidenced by the increase in fresh cassava imports in Puerto Rico after the 1980s.

Expanded exports, for those Caribbean and Central American countries which have been able to increase their commercial production of roots and tubers, have neither been a panacea for their agricultural sector or their general economy, given the instability that export trends in these crops have exhibited. In the case of the Dominican Republic, for example, Raynolds (1994b) documents how export earnings from tropical root crops increased significantly from 1979 to 1986, but declined precipitously afterwards when the Dominican state due to its fiscal crisis and changing domestic political priorities retired part of the incentives and export promotion policies it had formerly adopted.

Given this panorama it is possible to conclude that the production of R&T in Latin America and the Caribbean is still very fluid and undergoing constant restructuring, be it because increasing imports undermine the production conditions of local producers, or because erratic exports contribute little to the sustained viability of these sectors. In the Puerto Rican case, it is important to achieve an increase in the production of R&T by stabilizing its market conditions. The adoption of new processing and preservation of fresh produce technologies may be vital for increasing the contribution of local produce in local

consumption, and improve the viability of these sub sectors in the local economy. Yet, as recent contributions in the literature of technological change sustain: “technoscience is effective only if it succeeds in building networks that extend beyond the scientific laboratory and include farmers, agricultural extension agents, farm machinery manufacturers, processors, retailers, politicians, government officials and consumers (Juska and Busch, 1994: 583).” If the production of knowledge, the modification of commodities and the extension of networks do not occur simultaneously, the likelihood that new commodity sub sectors will emerge are dim. “Such an approach explicitly acknowledges that it does not matter how advanced the production of knowledge is or how capable of producing a given commodity producers are. Unless these three processes occur together, no economically viable commodity sub sector will emerge” (Juska and Busch, 1994: 583, 584). Although these conclusions were reached in a different commodity context, their advice seems also relevant to the situation of roots and tubers production and most commodity sub sectors in Puerto Rico and the world.

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TABLES AND FIGURES

Table 1. World Imports and Exports of Roots and Tubers, 1964 to 1999, in metric tons

Imports (mt)					
	1964	1974	1984	1994	1999
Yams	207	286	12,447	24,227	45,970
Cassava	39	0	0	0	2,272
Sweetpotato	18,759	199,291	148,205	679,324	80,052
Potato	3,513,824	3,825,415	4,820,451	7,688,567	7,758,389
Other R&T	57	1,191	33,654	28,227	94,044
Yautia	15	126	4,022	0	803
Taro	42	1,065	29,632	28,227	93,241
Total	3,532,886	4,026,183	5,014,757	8,420,345	7,980,727
Exports (mt)					
	1964	1974	1984	1994	1999
Yams	1282	12,423	21,126	30,007	24,656
Cassava	3206	0	86	1	1
Sweetpotato	6192	16,667	121,986	720,945	77,008
Potato	3,626,646	3,877,005	4,792,281	8,023,023	7,941,743
Other R&T	2538	15109	35559	106,344	125,692
Yautia	798	10,261	19,992	12,653	16,725
Taro	1740	4848	15,567	93,691	108,967
Total	3,639,864	3,921,204	4,971,038	8,880,320	8,169,100

Source: FAO Agriculture and Food Trade Databases

Table 2. Production, Consumption, Imports and Exports of Roots and Tubers, Puerto Rico, 1964, 1984 and 1999

	1964				Consump. (hwt)	Per capita (lbs)
	Production (hwt)	Imports	Exports			
Yams	298,000	0	45,337	252,663	9.85	
Cassava	129,000	7	0	129,007	5.03	
Sweetpotato	300,000	7,602	0	307,602	12	
Other R&T	471,113	1,965	65,318	407,760	16.06	
Yautia	356,000	1,965	47,593	310,372	12.1	
Taro	92,000	0	14,930	77,070	3.01	
Apio	23,113	0	2,795	20,318	0.95	
Total	1,198,113	9,574	110,655	1,097,032	42.94	

Fuente: Depto. de Agricultura. Oficina de Estadísticas Agrícolas. 1976. Consumo de Alimentos en Puerto Rico 1950/51-1973/74, Tomo 1, Cosechas. Santurce, P.R.:Depto. de Agricultura.

	1984				Consump. (hwt)	Per capita (lbs)
	Production (hwt)	Imports	Exports			
Yams	274,000	15,643	0	289,643	8.6	
Cassava	48,800	30,800	0	79,600	2.43	
Sweetpotato	182,000	229,714	0	411,714	12.2	
Other R&T	281,000	280,819	0	561,819	16.77	
Yautia	162,000	269,391	0	431,391	12.8	
Taro	68,000	11,428	0	79,428	2.42	
Apio	51,000	0	0	51,000	1.55	
Total	785,800	556,976	0	1,342,776	40	

Fuente: Depto. de Agricultura. Oficina de Estadísticas Agrícolas. 1989. Consumo de Alimentos en Puerto Rico (Cosechas), 1979/80 - 1986/87. Santurce, P.R.:Depto. de Agricultura.

	1999				Consump. (hwt)	Per capita (lbs)
	Production (hwt)	Imports	Exports			
Yams	80,768	237,144	0	317,912	8.36	
Cassava	16,531	199,501	0	216,032	5.68	
Sweetpotato	60,268	196,416	0	256,684	6.75	
Other R&T	90,481	348,102	0	438,583	11.54	
Yautia	29,706	289,349	0	319,055	8.39	
Taro	54,923	47,750	0	102,673	2.7	
Apio	5,852	11,003	0	16,855	0.44	
Total	248,048	981,163	0	1,229,211	32.33	

Fuente: Colegio de Agrónomos de Puerto Rico (2001).

Table 3. Number of publications on roots and tubers by crop and time period

	Before 1950	1950-1969	1970-1989	1990-1999	Total	Percentage
General	1	4	1	0	6	3.2
Sweet Potato	1	7	26	4	38	20.2
Potato	0	6	3	0	9	4.8
Yam	0	11	54	9	74	39.4
Cassava	2	1	9	1	13	6.9
Yautía (Tanier)	0	1	28	10	39	20.7
Malanga (Colocasia)	0	0	0	4	4	2.1
Apio (Arracacha)	0	0	1	4	5	2.7
Total	4	30	122	32	188	
Percentage	2.1	16	64.9	17	100	100

Source: JAUPR

Table 4. JAUPR publications on roots and tubers by major categories, 1925-1999

Category	Percent of Publications			
	Before 1950 (N=4)	1950-1969 (N=30)	1970-1989 (N=122)	1990-1999 (N=32)
Production technology	50	67	39	59
Cultural practices	0	30	9	16
Entomology, pl. pathology	25	20	5	9
Soil, fertilizers, herbicides	25	17	25	34
Plant manipulation	25	7	24	31
Breeding	0	0	13	3
Plant physiology	25	7	11	28
Post-harvest R&D	0	23	35	9
Socioeconomic research	0	3	2	0
Other (plant descriptions)	25	0	0	0