RESEARCH AND PRODUCTIVITY IN GRAIN PRODUCTION IN ASIA: THE COLONIAL HERITAGE

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Colonial agricultural research was directed mainly to export crops rather than the major foodgrains.[2] The lack of research on foodgrains is given as one of the reasons for the food shortages in the period after World War II. "Colonialism stunted indigenous agriculture by directing agricultural research only to export crops" (Lappé and Collins).

This paper examines the allocation of research resources and the impact of research on productivity in South and Southeast Asia. The paper also attempts to identify the main determinants of the allocation of agricultural research resources during the colonial period.

The Allocation of Research Resources

The initial scientific investigations and transfers of plant material within the British and Dutch empires during the 19th century were carried out through the botanical gardens in the colonies and the mother countries. The impact of research was mainly felt in commercial crops. The gardens were responsible for the transfer of quinine to the Netherlands East Indies and rubber to Malaya, and they made substantial contributions to the science of botany.

The initial efforts at systematically improving the commercial and food crops of the colonies through scientific research were made during the last quarter of the 19th century. Commodity based groups such as the sugar industry in Java and tea producers in India started research programmes. Around 1900, public sector agricultural research and improvement programmes were started in British India, the Philippines, Taiwan, and the Netherlands East Indies. Soon after 1900, several private companies started to do rubber research in Malaya.

Agricultural research in Asia initially concentrated on nonfoodgrains. In British India, the initial work by the government was on cotton, jute, sugarcane, tea, and wheat. Rice research also started before World War I, but after the initial investigations of the other crops. In Indonesia, the research stations for the major plantation crops were set up before 1900. Rice research started just after 1900. Taiwanese research was concentrated on sugarcane and rice. In Malaya, emphasis was clearly given to rubber. The Philippines was the only country in which the initial research work was mainly concentrated on foodgrains. The initial plant breeding work was in rice, maize, and tobacco in 1903, with cocoa and sugarcane research following a few years later. Thus research on the main foodgrains of all of these countries had started by 1915.

I have assembled the available data on agricultural research and development expenditures (table 1). It is possible to break down the research expenditures in the Netherlands East Indies, Malaya, and Ceylon by foodgrains and non-foodgrains, (which, in those countries, corresponded to foodgrains and export crops) and by type of institution which was doing the research. I have also included total expenditures on agricultural development for those countries and for India to give a rough idea of the relative size of the different research programmes. Research expenditures on export crops (nonfoodgrains) were 6 to 7 times as much as the expenditures on foodgrains. However, the public sector research programme did not put as much emphasis on research on export crops (column 1). It is also important to note that the Philippines and India did not place as much emphasis on export crops. An analysis of the Punjab agricultural research programme, the largest provincial research programme in British India, indicates that in 1928 less than one third of the scientific manpower of the department was working on export crops (Pray, 1981, p. 55). If the small private sector research programme were included, export crops would still be receiving

the attention of less than half the researchers. A comparison of the annual reports of the Malayan Department of Agriculture and the Philippines Bureau of Plant Industry makes it clear that the relative importance of research on foodgrains such as rice and maize is far greater in the Philippines. At the other end of the spectrum, Taiwanese research concentrated on rice and sugarcane which were both important exports.

Table 1. Agricultural Research and Development Expenditures, 1926

Item	Government	Commodity groups	Private companies	Total
		£'000		
Netherlands East Indies:				
Foodgrains	38	0	0	38
Nonfoodgrains	20	207	50	277
Total research	58	207	50	315
Total agriculture	255	207	50	482
Malaya:				
Foodgrains	13	0	0	13
Nonfoodgrains	47	45	5	97
Total research	60	45	5	110
Total agriculture	63	45	5	113
Ceylon:				
Foodgrains	11	0	0	11
Nonfoodgrains	33	27	0	60
Total research	44	27	0	71
Total agriculture	55	27	0	82
India:				
Total agriculture	984	73	na	1,057

The only standardized measure that indicates the division of research resources in all of these countries over time is the number of published articles which were abstracted in *Plant Breeding Abstracts* (table 2). These numbers have been shown to be closely related to research expenditures (Boyce and Evenson), and a comparison to 1926 expenditures for Malaya and the Netherlands East Indies (table 1) indicates that they are also reasonable measures for the period before 1940. India had the largest share of articles on foodgrains. The Philippines had about equal shares on foodgrains and nonfoodgrains. Indonesia had almost all of its articles on export crops.

The greatest impact of research was through the development of improved crop varieties. Japanese scientists in Taiwan were able to introduce improved varieties of rice from Japan after a period of experimentation and modification of agronomic practices. They also brought in high yielding sugarcane from Java. British Indian, Dutch, U.S., and Philippine scientists introduced some improved varieties from local material through pureline selection and crossbreeding. Rubber productivity was improved through improved clones, but also new methods of processing rubber and improved husbandry practices had an important impact on productivity.

Few studies have measured the impact of colonial agricultural research. Pee calculated the internal rate of return of Malaysian rubber research and development investments, most of which took place during the colonial period, to be 24 to 25 percent. Pray (1978) calculated the rate of return to the investment in public sector research and extension in the British Punjab to be between 36 and 44 percent. Carr and Myers calculated that the ratio of discounted benefits to discounted costs of rice research in Taiwan before 1942 was at least 1.33 and perhaps as much as 3.52. Thus some colonial research efforts seem to have had high payoffs.

Table 2. Journal Articles by Commodity

Item	1935-1939		1955-1961		1969-1973	
	Articles	Percent	Articles	Percent	Articles	Percent
India:						
Foodgrains	33	62	112	47	328	80
Nonfoodgrains	20	38	125	53	84	20
Nonexports	39	74	160	68	328	80
Exports	14	26	77	32	84	20
Philippines:						
Foodgrains	2	50	12	80	29	83
Nonfoodgrains	2	50	3	20	6	17
Nonexports	2	50	12	80	29	83
Exports	2	50	3	20	6	17
Indonesia:						
Foodgrains	1	5	10	61	1	20
Nonfoodgrains	19	95	6	39	4	80
Nonexports	1	5	0	61	1	20
Exports	19	95	6	39	4	80
Taiwan:						
Foodgrains	1	50	15	58	20	53
Nonfoodgrains	1	50	11	32	18	47
Nonexports	0	0	3	12	6	16
Exports	2	100	23	88	32	84
Malaysia:						
Foodgrains	1	25	4	50	2	13
Nonfoodgrains	3	75	4	50	13	87
Nonexports	1	25	4	50	2	13
Exports	3	75	4	50	13	87

Table 3 shows the percentage of acreage under improved varieties and the growth in yield per acre of the major foodgrain, cash, and export crops during the colonial period. It supports the positive relationship between research expenditure and productivity. Before World War II, the percentage of area under new varieties and the growth in yield per acre was generally greatest in the nonfoodgrains. Indonesia, with the strongest research programme on export crops, produced substantial gains in yield per acre in sugar (the main export) and rubber but not in rice. Taiwan, which had a relatively balanced programme for cash and foodgrains, experienced gains in both areas.

In Malaysia, rice yields went up faster than rubber yields. However, a number of productivity increasing technical changes were adopted by rubber planters which do not show up in yield per acre (Bauer). In addition, the lag between the development of a new rubber clone and the time at which it starts bearing is many years longer than it takes to develop and adopt new rice varieties. In India, the only productivity growth was in the nonfoodgrains despite a substantial investment in foodgrain research. There is considerable scepticism among scholars about the accuracy of the official yield per acre statistics of the foodgrains. However, even if these figures are biased downwards, the data on the acreage under new varieties indicate that the improved varieties of foodgrains were not nearly as widely adopted as the nonfoodgrain varieties. More data on actual expenditures by commodity will be required to sort out whether this is a contradiction to the pattern or not. In the Philippines, productivity of both the foodgrains and cash crops grew. However, Hooley and Ruttan report that there was no important new rice technology. Therefore, the productivity growth must have been due to other factors.

In summary, the colonial period is much more complex than the simplistic picture painted by Lappe and Collins. All the colonialists were doing some research on foodgrains. This led to substantial yield increases in most colonies. Furthermore, the end of colonialism led to the allocation of a higher percentage of resources to cash and export crops. However, it is correct to say that export and cash crops got most of the resources during the colonial period.

What Determined the Allocation of Resources During the Colonial Period?

The allocation of research resources between different commodities during the colonial period was the result of the interaction of a number of different interest groups. Their impact on the research system was determined by their perception of the benefits from research and their political power. At present I do not have sufficient data to estimate statistically the relative importance of these different groups. Thus, in this section I present the various interests for which these groups lobbied, and give examples of their role in determining the allocation of research resources.

The import requirements of the colonial powers were very important. This was clearly the case for rice from Taiwan, and cotton, jute, and wheat from British India. Hayami and Ruttan have documented the causal relationship between rising Japanese demand for rice and expenditures on rice research in Taiwan. In 1904-1905, India was the largest supplier of wheat to England. At about the same time, the British cotton industry was looking for an inexpensive substitute for American cotton which was in short supply due to the boll weevil (Pray, 1981). However, in India this factor lost much of its importance after World War I when the importance of those exports to Britain declined.

Table 3. Acreage Under New Varieties and Growth Rate of Yield Per Acre

Item	Period			Yield/acre growth rate	Area under new varieties	
	Years			Percent/year	Years	Percent
India:						
Rice	1909-1911	to	1944-1946	-0.75	1938	5
Wheat	1909-1911	to	1944-1946	-0.59	1938	26
Foodgrains	1909-1911	to	1944-1946	-0.42	1938	7
Sugarcane	1909-1911	to	1944-1946	0.59	1938	76
Cotton	1909-1911	to	1944-1946	0.90	1938	35
Tea	1909-1911	to	1944-1946	1.27	1938	na
Jute	1909-1911	to	1944-1946	0.22	1938	62
Nonfoodgrains	1909-1911	to	1944-1946	1.07	1938	24
Philippines:						
Rice	1911-1913	to	1938-1940	2.24	1948	35
Maize	1909-1911	to	1952-1954	0.32	na	na
Coconuts	1920-1921	to	1947-1948	0.72	1940	0
Sugarcane	1936-1937	to	1952-1953	2.18	na	na
Indonesia:						
Rice	1911-1913	to	1938-1940	-0.51	1937	3
Sugarcane	1910-1914	to	1938-1942	1.76	1930s	94
Rubber	1930	to	1950	0.77	na	na
Taiwan:						
Rice	1911-1913	to	1937-1939	5.05	1935	46
Sugarcane	1910-1914	to	1948-1952	3.46	1930	99
Malaysia:						
Rice	1921-1923	to	1961-1963	2.11	na	na
Rubber	1930-1932	to	1961-1963	0.67	1961-1963	33

The foodgrain requirements of the colonies were another important factor. Foodgrain shortages and high prices could be very destabilizing factors to a colonial regime. At the same time, there was pressure from voters and colonialists from the home country to do something about famines such as the ones that hit India in the last quarter of the 19th century. Finally, plantation and factory owners in the colonies were concerned about the price of food which was the main wage good. The decision to initiate research on foodgrains in British India was undoubtedly a combination of the fear of famines and the needs of Britain for wheat. The Malayan rice research programme developed between 1918 and 1920 was also due to a combination of these factors (Lim).

Some specific commodities were grown by small groups of producers or used by a well-organized industry in the colony. Sometimes they formed a group and taxed themselves to do research. Sugar and the plantation crops of the Netherlands East Indies are good examples of this. Tea producers in India and rubber producers in Malaya did the same thing. The Indian tea association then lobbied for government assistance for the private tea research institute. In Malaya, rubber producers got the government to sanction a tax on rubber production that was used to finance a rubber research institute. In this way, they got around the free rider problem. Another pattern is found in the cotton and jute industries in India which had even closer links with the government. The government sanctioned a tax on cotton to support the Indian Central Cotton Committee which was a semi-government organization with its own research stations. The Committee also funded a substantial amount of research at the public sector research stations. The jute industry was able to convince the Indian government to finance research from the general revenue. The jute industry also gave the government financial assistance for certain projects. In the 1930s, the Indian Central Jute Committee was set up and funded through a tax on exports.

A fourth interest group which undoubtedly affected at least some government officials' decisions was the small scale farmers of the colony. By the mid-1920s, scientists had proved the value of agricultural research by improving wheat and export crops such as cotton and jute in India. This allowed concerned bureaucrats and scientists to press the research system for more work on subsistence food crops. Thus in the mid-1920s, scientists started working on the other important crops of the Punjab besides wheat and cotton.

A fifth factor that may have been important for some crops was their contribution to the government revenue. The fact that revenue from the tobacco industry made up over a quarter of the total revenue of the Philippine government during the 1930s (Paguirigan) undoubtedly had some effect on the government's decision to fund tobacco research.

The two dominant forces in the early stages of colonial agricultural research seem to have been the groups and officials representing the import needs of the mother country, and the plantation or industrial groups which were interested in a specific crop. The two colonies that do not fit as well into this pattern are British India and the Philippines. In India, the concern about famine was clearly an important factor. In the Philippines, the absence of large American plantations and the fact that the United States had no pressing need for Philippine products meant that the interests of Philippine farmers and consumers had more influence on research policy.

Issues for Further Research

Was the allocation of research resources among foodgrains, cash, and export crops efficient? It is not possible to give a definitive answer to that question at present. However, it seems clear that in some colonies such as the Netherlands East Indies and Malaya more resources should have been invested in food crops. In 1929, the value of rice grown on Java was 609 million florins

(Wickizer and Bennett) while the value of the agricultural commodities exported from Java was 466 million florins. Thus, the 19 to 1 ratio of publications in favour of export crops would be hard to justify on grounds of economic efficiency. A similar argument could be made for Malaya. However, in Taiwan, the Philippines, and British India, a rigorous exploration of this question is required. That would mean that a simulated growth rate of agricultural production assuming more research on foodgrains would have to be compared with the actual growth rate of production. The difference would be the benefit of more foodgrain research.

These calculations have not as yet been made, but it is clear that the Green Revolution is not likely to have occurred during the colonial period in British India since the price of fertilizer, a key ingredient in the Green Revolution, was still very high (Pray, 1981). It is also important to note that in the absence of the interest groups for export crops which supported research both financially and politically, agricultural research would have started at a later date and the total amount spent on research would have been less. This should also be included in the simulation in that a shift of resources away from export crops would decrease political support for the system and thus decrease the total budget of the research system.

A second issue which needs to be explored is the income distribution impact of the allocation of resources. Colonial research on export crops ensured that more gains in consumer surplus went to consumers outside the colony than to local consumers. However, the size of the gains to foreign consumers depended on the elasticity of demand for the commodity. If the country produced a large share of world supplies, new technology which spreads widely could bring world prices down and the new technology could be detrimental to the welfare of producers. If the country had a small share of the world market, then most of the total benefits would stay in the country and would go to the producers of the commodity. The distribution of benefits between producers and consumers for an imported commodity or one which was not traded would also depend on the nature of the supply and demand curves for that commodity. However, the benefits would go to farmers and consumers in the colony rather than being shipped back to the consumers of Great Britain, Japan, the Netherlands, or the United States.

Conclusion

The initial hypothesis that colonial research was primarily directed to export crops is supported by the available evidence on resource allocation in some countries and the data on productivity growth in others. The problem is that these patterns are not always consistent. In Taiwan, Indonesia, and Malaysia, the resource allocation is reasonably consistent with what we know about productivity growth. In the Philippines and India, there was little growth in foodgrain productivity due to technical change despite relativley large research investments. Thus other factors such as the state of knowledge about certain crops and the price of fertilizer may have presented constraints to food crop productivity which cash crops did not face.

The hypothesis of the inefficiency of the actual allocation of research resources has not been tested. However, it seems clear that in Indonesia and Malaysia too much money was spent on export crops. It was also noted that in the absence of research on cash and export crops, agricultural research would probably have started later and had a much smaller total budget.

Notes

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[2]Foodgrains, cash crops, and export crops are frequently overlapping categories. In Asia, the main foodgrain is rice, followed by wheat and maize. Foodgrains constitute the main cash and export crops in several Asian countries, notably the rice exports of Korea, Thailand, and Burma. Nonfoodgrain cash crops can also be divided into crops for local consumption and crops for exports.

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