AGRICULTURAL SCIENCE AND TECHNOLOGY INDICATORS

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MALAYSIA

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This brief reviews the major investment and institutional trends in public agricultural research in Malaysia since the 1981, using recent data collected under the Agricultural Science and Technology Indicators (ASTI) initiative (IFPRI–MARDI 2003–04).[1]

INTRODUCTION

Malaysia attained independence from the British in 1957. In the three decades that followed, agriculture constituted a substantial share of gross domestic product (GDP), driving economic growth and a gradual shift in the country's economic base toward manufacturing and services. Since the 1990s, rapid export-led industrialization has prompted further social and economic change, so Malaysia is now well on the way to achieving developed-country status. Parallel with these developments, by 2003 less than 20 percent of the total labor force was active in the agricultural sector compared with over 60 percent in the early 1960s (FAO 2005), and agriculture accounted for less than 10 percent of total GDP— down from 33 percent (World Bank 2004). Nevertheless, agriculture continues to represent an important source of income for Malaysia's rural population. Food crop production remains important, and the country

Table 1—Composition of agricultural research expenditures and total researchers, 2002

Type of agency	Spending		Researchers	Share		Agencies in sample[a]
	2000 Malaysian ringgits	2000 international dollars		Spending	Researchers	
	(*millions*)		(*fte's*)	(*percent*)		(*number*)
Public agencies						
Government						
MARDI	164.9	100.1	410.0	24.6	33.9	1
VRI	7.5	4.6	22.0	1.1	1.8	1
FRI	34.2	20.8	58.8	5.1	4.9	1
FRIM	134.7	81.7	139.0	20.1	11.4	1
MRB	31.5	19.1	33.0	4.7	2.7	1
MCB	24.8	15.0	19.5	3.7	1.6	1
MPOB	156.8	95.2	188.0	23.4	15.5	1
MINT	0.9	0.6	2.8	0.1	0.2	1
Sabah and Sarawak	26.5	16.1	91.2	4.0	7.5	4
Higher education[c]	51.5	31.2	153.3	7.7	12.7	8
Subtotal	*633.4*	*384.4*	*1,117.6*	*95.0*	*92.4*	*20*
Private enterprises[d]	33.4	20.3	91.5	5.0	7.6	16
Total	**666.8**	**404.7**	**1,209.1**	**100**	**100**	**36**

Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04).
[a] See note 2 for a list of the 36 agencies included in this sample.
[b] Expenditures for the Department of Agriculture, Sabah, are estimates based on average expenditures per researcher at the three other government agencies in Sabah and Sarawak.
[c] Expenditures for the higher-education sector in our sample are estimates based on average expenditures per researcher at MARDI, VRI, FRI, and MINT. The 662 faculty staff employed in the eight higher-education agencies spent between 20 and 30 percent of their time on research, resulting in 153 fte researchers.
[d] Expenditures for eight private enterprises are estimates based on average expenditures per researcher for the private enterprises for which data were available.

KEY TRENDS

- During 1981–2002, total agricultural researcher numbers in Malaysia rose steadily, and public agricultural R&D expenditures, in constant prices, almost tripled.
- Malaysia's principal agricultural research agency, the Malaysian Agricultural Research and Development Institute (MARDI), accounted for about one-third of the country's agricultural research staff and a quarter of its agricultural R&D spending in 2002.
- In 2002, spending by Malaysia's three major commodity boards—the Malaysian Palm Oil Board (MPOB), the Malaysian Rubber Board (MRB), and the Malaysian Cocoa Board (MCB)—constituted one-third of the country's agricultural research expenditures.
- Despite rising private-sector agricultural R&D investments in absolute terms, the share of private-sector agricultural research has fallen in recent years given rapidly increasing investments by the government and higher-education agencies.
- Financing of Malaysian agricultural R&D has undergone significant reform in recent years through the Intensification for Research Priority Areas (IRPA) program, which has also encouraged cooperation between the country's public and private R&D agencies.

ABOUT ASTI

The Agricultural Science and Technology Indicators (ASTI) initiative comprises a network of national, regional, and international agricultural R&D agencies and is managed by the International Service for National Agricultural Research (ISNAR) division of the International Food Policy Research Institute (IFPRI). The ASTI initiative compiles, processes, and makes available internationally comparable data on institutional developments and investments in public and private agricultural R&D worldwide, and analyses and reports on these trends in the form of occasional policy digests for research policy formulation and priority setting purposes.

Primary funding for the ASTI initiative's survey round in Asia was provided by the CGIAR Finance Committee/World Bank.

maintains a competitive advantage in the production of plantation crops, especially oil palm. Given that productivity gains are critical in maintaining and enhancing competitiveness of these commodities, agricultural research and development (R&D) is a high priority in national development planning.

Science and Technology Policy and Investment

Malaysia's total (agricultural and nonagricultural) R&D expenditures tripled in constant prices from 0.8 billion 2000 ringgit (RM) in 1992, to RM2.5 billion in 2002 (calculated from MASTIC 2004).[2] About one third of total research investments were made by the public sector while the private sector accounted for the remaining two thirds. Most of this growth occurred after the national government launched its seventh five-year plan in 1996, which stressed the importance of science and technology for economic development.

Malaysia's R&D expenditures are largely generated through internal sources such as government budgetary allocations). In 2002, these internal funds represented a 70 percent share; foreign sources, including the parent companies of multinationals, constituted a 12 percent share; 10 percent was derived from the Intensification of Research in Priority Areas (IRPA) program (see page 8), and the remainder was raised through federal and state government funds. Most of Malaysia's 2002 R&D budget was spent on engineering sciences (39 percent) and information and communication technologies (24 percent); agricultural sciences received only 4 percent.

Total R&D expenditures represented 0.69 percent of Malaysia's GDP in 2002, which is relatively high compared with some countries in the region (for example, Thailand, at 0.24 percent and the Philippines at 0.11 percent) but well below the ratios of India (0.78), China (1,09), and many developed countries (for example, the United States, at 2.72 percent; Japan, at 3.07 percent; South Korea, at 2.53 percent (MASTIC 2004). By 2010, Malaysia aims to increase its R&D expenditures to at least 1.5 percent of GDP (MOSTI 2003).

INSTITUTIONAL DEVELOPMENTS IN AGRICULTURAL S&T

We identified over 40 agencies involved in agricultural research in Malaysia in 2002, including a number of private-sector agencies.[3] That year, the 36 agencies for which data were available employed over 1,200 full-time equivalent (fte) researchers and spent 667 million ringgit at constant prices of the year 2000 on agricultural R&D, the equivalent of 405 million international dollars in 2000 constant prices (Table 1).[4]

The Malaysian Agricultural Research and Development Institute (MARDI) is the country's primary agricultural R&D agency. In 2002, it accounted for one-third of the country's agricultural researchers (410 fte researchers) and a quarter of its agricultural R&D spending. Established in 1969, MARDI falls under the Ministry of Agriculture and Agro-Based Industry (MOA), is governed by a Board of Directors representing both public and private interests, and is headquartered in the state of Selangor (see *A Short History on Government-Based Agricultural Research* below). Research conducted focuses on scientific, technical, economic, and sociological issues related to the production, processing, and use of crops (excluding cocoa, rubber, and oil palm) and livestock (MARDI 2005). The institute has three main branches: Research, Technology Transfer and Commercialization, and Operations. The Research Branch has seven research centers focusing on horticulture, rice and industrial crops, food technology, livestock, strategic resources, biotechnology, and mechanization and automation. The Technology Transfer and Commercialization Branch has

A Short History of Government-Based Agricultural Research

Agricultural research in Malaysia dates back to the early 1900s. While the Department of Agriculture (DOA) was established in 1905, organized agricultural research first began in 1910, when the Dunlop Research Station was established by Dunlop Plantations. In 1920, the Chemara Research Station was opened by Kumpalan Guthrie, and the following year the Prang Besar Research Station was established by Harrisons & Crossfield (H&C). All of these ventures were private undertakings.

Under colonial rule, Malaysia's agricultural development policy was primarily concerned with British needs and focused largely on rubber. As rubber cultivation spread from large private plantations to smallholders, increased national research needs arose; hence the Rubber Research Institute of Malaysia (RRIM) was created in 1925, serving the needs of both smallholders and large plantations. While DOA administered research on other crops at this time, Malaysia did not begin to exploit the potential of export commodities and domestic food crops until the 1960s.

After attaining independence in 1957, Malaysia's government began to focus on agricultural development. Again, the private sector was first to realize the economic potential of crops such as palm oil and coconut. HMPB created the Oil Palm Research station in 1954, and United Plantations Berhad established the United Plantation Research Department in 1964. Five years later, the Malaysian Agricultural Research Development Institute (MARDI) took over DOA's role, and around the same time, Malaysia replaced Nigeria as the world's leading producer and exporter of palm oil, which eventually led to the 1979 creation of the Palm Oil Research Institute of Malaysia (PORIM).

Even though Malaysia invested in agricultural research very early, it was not until the government's fifth development plan (1986–90) that agricultural research and development became an established component of national development planning. The creation of the National Council on Scientific Research and Development (MPKSN) was another important factor in the formulation of national R&D policy. In 1992, MARDI established a subsidiary company, MARDITECH Corporation, as a means of partnering with private firms to commercialize R&D outputs. MARDITECH offers joint equity with private companies to commercialize potential agricultural and food technologies and to provide consultancy training services to other agencies.

The Malaysian Cocoa Board (MCB) was established in 1988 to develop the country's cocoa industry. The Rubber Research Institute of Malaysia (RRIM), Malaysian Rubber Research and Development Board (MRRDB), and Malaysian Rubber Exchange and Licensing Board (MRELB) were merged in 1998 to form the Malaysian Rubber Board (MRB). Similarly, the Palm Oil Research and Development Board (PORDB), PORIM, and the Palm Oil Registration and Licensing Authority (PORLA) were merged to form the Malaysian Palm Oil Board (MPOB) in 2000.

Sources: Hashim (1992); MCB (2005); MRB (2005).

four centers and two units focusing on the dissemination of the institute's research results, and one research center, the Economy and Technology Management Research Centre, providing support services.[5] All of the centers are based at the institute's headquarters, and research activities are undertaken by 29 regional research stations (MARDI 2005).

Three commodity boards—the Malaysian Palm Oil Board (MPOB), the Malaysian Rubber Board (MRB), and the Malaysian Cocoa Board (MCB)—conduct research on Malaysia's principal export commodities under the administrative responsibility of the Ministry of Plantation Enterprises and Commodity (MPEC).[6] In 2002, these three boards together accounted for 20 percent of Malaysia's agricultural research staff (in ftes) and close to one-third of the country's agricultural R&D expenditures.

Palm oil is the country's primary agricultural commodity. MPOB promotes national policies and priorities for the industry's development and administration and in 2002 employed 188 fte researchers (MPOB 2005). MRB plays a similar role for Malaysia's rubber industry. Its principal objective is to support the development and modernization of the industry, including rubber tree cultivation, extracting and processing raw rubber, and producing and marketing rubber and related products—the dominant focus in recent years (MRB 2005). MRB employed 33 fte researchers in 2002. MCB has represented Malaysia's cocoa industry since its foundation in 1988 (a responsibility previously held by MARDI). In 2002, MRB employed 20 fte researchers focusing on cocoa production, processing, storage, and consumption (MCB 2005).

Eight other government agencies conduct agricultural R&D in Malaysia. Four of these are located in Peninsular Malaysia where most of the country's population lives and most of the agricultural production takes place. In 2002, these four agencies accounted for close to one fifth of Malaysia's agricultural research staff and over a quarter of the country's research spending. The Forestry Research Institute Malaysia (FRIM), the largest of these public agencies, is administered by the Ministry of Natural Resources and the Environment (MNRE) and is considered a world leader in tropical forestry research. FRIM is headquartered in Kepong, just outside Kuala Lumpur, and oversees six additional research stations across the country's various agroforestry zones. Its research activities are structured under three divisions: forestry, product development, and biotechnology. In 2002 FRIM employed 139 fte researchers (FRIM 2005). The Veterinary Research Institute (VRI) under MOA's Department of Veterinary Services is based in the state of Perak. In 2002, it employed 22 fte researchers focusing on three primary areas: animal diseases, technology development, and product development (VRI 1997). The Fisheries Research Institute (FRI) is headquartered in the state of Penang and employed 59 fte researchers in 2002 focusing on management of marine resources, aquaculture, aquatic ecology, biotechnology, fisheries products, and fish diseases (FRI 2004). The Malaysian Institute for Nuclear Technology Research (MINT) employed 3 fte researchers in 2002 working on agrotechnology and biosciences at the institute's Selangor-based laboratories.

A distinction was made between agencies in Peninsular Malaysia and those in the oil and timber rich states of Sabah and Sarawak on the island of Borneo. Whilst agricultural R&D in Peninsular Malaysia is conducted by dedicated federal R&D institutes, this is not the case in the states of Sabah and Sarawak. In these two states, the state-level Departments of Agriculture, Forestry, and Fisheries have their own dedicated research units that cater for these states' particular R&D needs. These units work closely with the federal peninsula-based R&D institutes, either through the research stations that these federal institutes operate in Sabah and Sarawak (MARDI, for example, operates three research stations in Sabah and Sarawak), or through the federal institutes' headquarters based in Peninsular Malaysia. The four state-level government agencies are the Departments of Agriculture in Sabah and Sarawak, the Forest Research Centre in Sarawak the Fisheries Research Institute in Sarawak. Together these four agencies employed 91 fte researchers in 2002, representing 8 percent of Malaysia's agricultural research staff and 4 percent of its research spending.

Ten higher-education agencies conduct agricultural research activities in Malaysia. The eight agencies for which data were available employed 153 fte researchers in 2002, representing 13 percent of the country's total agricultural research staff that year.[7] Four of these eight agencies are faculties of the Universiti Putra Malaysia (UPM)—the faculties of agriculture, veterinary science, forestry, and food science and biotechnology—which together employed 77 fte researches in 2002. The Faculty of Science and Technology of the Universiti Kebangsaan Malaysia (UKM), located in Selangor Darul Ehsan, employed 41 fte researchers in 2002. Research staff at both universities largely focus on crops (tobacco, oil palm, vegetables, and fruits) and also on natural resources and livestock. UPM has a strong biotechnology focus. The Faculty of Food Science and Biotechnology received significant support under the Sixth Malaysia Plan, which promoted R&D on food science, food technology, and biotechnology. This funding, along with support from the Japan International Cooperation Agency (JICA) through a program on biotechnology development, enabled the establishment of excellent facilities and equipment for education and research. The three remaining higher-education agencies employed fewer than 20 fte researchers each in 2002, and their research covered a wide range of themes including crops, forestry, and fisheries.

Collaboration

Malaysia's agricultural R&D agencies participate in a significant amount of collaborative research nationally, regionally, and on an international basis. National collaborative arrangements are in place among the government, higher-education, and private agencies, much of which has been initiated by the IRPA program. Continued efforts to establish and consolidate national R&D linkages should further strengthen these collaborations in the future. MARDI reported joint activities with about 40 national and international research organizations and networks, including the International Plant Genetic Resources Institute (IPGRI), the International Rice Research Institute (IRRI), JICA, the International Board for Plant Genetic Resources (IBPGR), the Asian Vegetable Research and Development Institute (AVRDC), and the Australian Centre for International Agricultural Research (ACIAR). Cooperation takes the form of research projects, networking and information sharing activities, and the exchange of plant and genetic material. FRIM actively seeks the participation of Malaysia's higher-education and private-sector

agencies in its research activities. FRIM also works closely with forestry research agencies both in the region and around the world. MPOB is the world leader in palm oil research. It works closely with Malaysia's private and higher-education sectors and with West African research agencies working on oil palm. MPOB also reported cooperation with the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia), Plant Research International (PRI, the Netherlands), the Center of International Agricultural Research Cooperation for Development (CIRAD, France), the Xian Research Institutes for Fats and Oils (China), and the Royal Melbourne Institute of Technology (RMIT University, Australia). MRB has strong linkages with the national rubber research institutes of Thailand and Vietnam, the International Rubber Research and Development Board (IRRDB), and the International Rubber Study Group (IRSG). The principal international foreign scientific partners of MCB are the International Cocoa Organization (ICCO) and the Indonesia Cocoa and Coffee Research Institute (ICCRI).

HUMAN AND FINANCIAL RESOURCES IN PUBLIC AGRICULTURAL R&D

Overall Trends

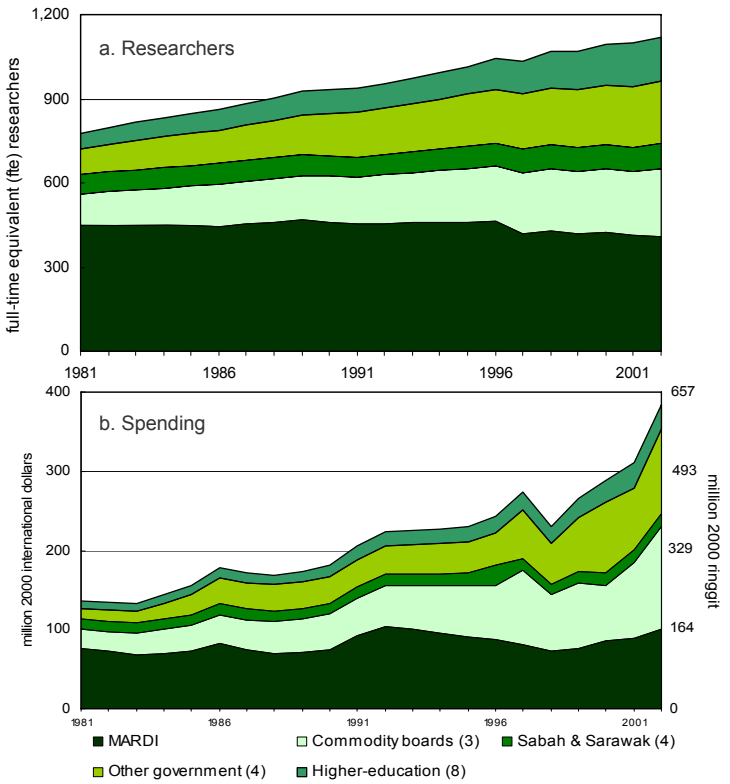
Total public agricultural researcher numbers in Malaysia rose at an average rate of 1.7 percent per year during 1981–2002, increasing from 778 to 1,118 ftes (Figure 1a). Growth in the higher-education sector was strongest. Fte researcher numbers almost tripled, from 56 to 153, because new higher-education agencies conducting agricultural R&D were established—the Faculty of Resource Sciences and Technology at Universiti Malaysia Sarawak (UNIMAS) in 1993 and the Faculty of Agrotechnology and Food Science at Kolej Universiti Sains dan Teknologi Malaysia (KUSTEM) in 1996—and due to growth at the other six higher-education agencies.

Over the same time frame, total fte researcher numbers at the four Peninsula-based and four Sabah and Sarawak-based public agencies grew by 4.3 and 1.2 percent, respectively, per year. Research staff numbers at MPOB and MCB also grew over this period, but numbers at MRB fell from 66 in 1991 to 33 in 2002 due to declining rubber exports; this resulted in an average growth trend for the three commodity boards of 3.4 percent per year during 1981–2002. Given the labor-intensive nature of rubber tapping, growing agricultural labor shortages, and the comparatively high cost of labor in Malaysia, countries like Thailand, Indonesia, and Vietnam are increasingly overtaking Malaysia in rubber production and exports. The trend in researcher numbers at MCB, while erratic, increased overall despite declining cocoa production stemming from rapid urbanization, crop disease, and falling world market prices in the 1990s.[8] Research staffing is therefore expected to contract at MCB in the years to come. On the other hand, the market potential for palm oil has been positive. This is reflected in the rise of MPOB's researcher numbers, which doubled from 97 in 1991 to 188 in 2002, positioning MPOB as Malaysia's second-largest agricultural research agency after MARDI in terms of research staff.

Growth in Malaysia's overall agricultural research capacity predominantly occurred in the 1970s and was followed by a recruitment freeze in the 1980s and 1990s. As a result, the older government and higher-education agencies, including MARDI, are facing a staffing gap between their senior researchers who are approaching retirement and their younger staff still in their late 20s and early 30s. MARDI's total fte researcher numbers, for example, dropped from 463 in 1996 to 410 in 2002. Attempts to redress this problem in more recent years have led to accelerated recruitment, particularly in areas such as biotechnology and strategic research. Fte researcher numbers had rebounded to 465 in 2004, and MARDI now aims to increase its total research staff to 650 by 2010, maintaining a one-third share of PhD-qualified researchers.

Total public agricultural research expenditures in Malaysia nearly tripled in constant prices during 1981–2002, from $136 million in 1981 to $384 million in 2002 (Figure 1b). Total spending increased rapidly from 2000 to 2002 as a result of a doubling of expenditures at MCB, MPOB, and FRI. Spending at the other government agencies also increased over this period, albeit at a slower rate. Overall, MARDI's expenditures grew by 1.1 percent per year during 1981–2002, following an erratic trend, while combined spending by the three commodity boards (led by MPOB) increased more than fivefold. Funding for MPOB and MRB is largely derived from a cess (tax) levied on palm oil and rubber exports, respectively. As a result, increased exports of oil palm caused an extraordinary rise in MPOB's research expenditures, from just $8 million in 1981 to $95 million in 2002. MCB's expenditures increased substantially (primarily a reflection of its 1988 establishment), while

Figure 1—Public agricultural R&D trends, 1991-2002

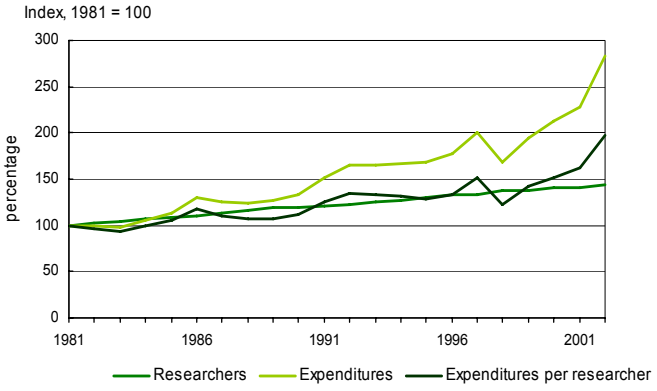


Sources: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04); ACU (various years); Hashim (1990 and 1992); ISNAR, IFARD, and AOAD (1985); and Mustapha (1981).
Notes: See Table 1. Figures in parentheses indicate the number of agencies in each category. Total researcher numbers and expenditures for 1982–85, 1987–90, and 1992–95 have been interpolated. Underlying data are available at the ASTI website (www.asti.cgiar.org).

expenditures at MRB remained relatively constant. Combined research spending by the four public agencies based in Peninsular Malaysia increased almost sevenfold during 1981–2002. Most of this growth occurred after 1997, during which time FRI and FRIM invested heavily in their R&D infrastructure. In contrast, the combined agricultural research spending of the four Sabah and Sarawak-based public agencies grew slowly during 1981–2002 at just 1.0 percent annually. Unsurprisingly, growth in agricultural research expenditures by the higher-education agencies was strong—at an estimated 6.0 percent per year—as a result of the aforementioned growth of agricultural research staffing. These impressive overall growth rates are unusual in comparison with many of Malaysia's Asian counterparts, whose agricultural research budgets have grown far more modestly or even stagnated over a similar time frame.

Malaysia's combined growth of researcher numbers and expenditures resulted in a doubling of average spending per scientist from $175,000 in 1981 to $344,000 in 2002 (Figure 2). These averages, however, mask considerable variations among the sample agencies. Spending per researcher at the three commodity boards and one government agency (FRIM), for example, was above $500,000 in 2002. In contrast, agricultural research expenditures at MARDI measured $244,000 per researcher the same year, and three of the four Sabah and Sarawak-based public agencies had spending-per-scientist levels below $200,000. The variations can be explained in part by the focus of the research because activities related to oil palm, rubber, timber, and cocoa are more generously funded than activities focusing on food crops.

Figure 2—Trends in public expenditures, researchers, and expenditures per researcher, 1981-2002

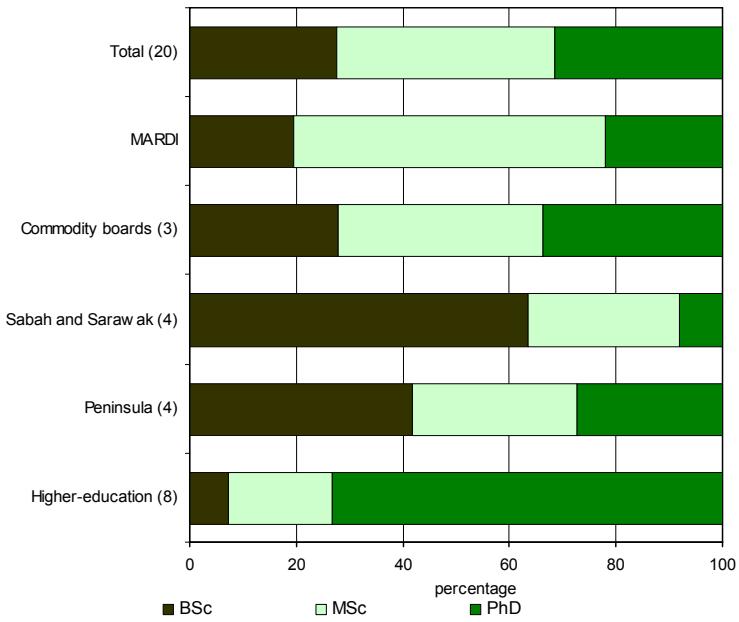


Sources: See Figure 1.
Notes: See Figure 1.

Human Resources

In 2002, over two-thirds of the 1,118 fte researchers in our 20-agency sample were trained to the postgraduate level, and 31 percent held PhD degrees (Figure 3). The eight higher-education agencies reported a significantly higher share of research staff trained to postgraduate level (93 percent) compared with the public agencies (69 percent), which is consistent with findings in most countries of the region and developing countries worldwide.

Figure 3—Educational attainment of researchers by institutional category, 2002

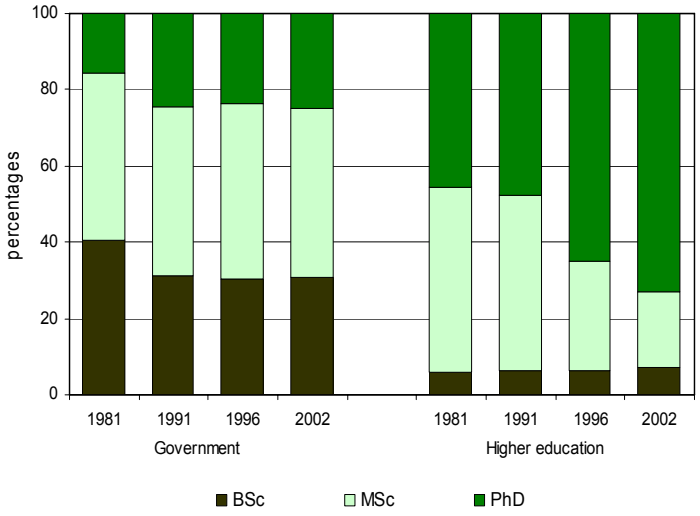


Source: Compiled by authors from ASTI survey data (IFPRI–NARI 2003-04).
Note: Figures in parentheses indicate the number of agencies in each category.

Though a relatively high share of MARDI's researchers held postgraduate degrees (81 percent), only 22 percent held PhD degrees in 2002, and this share had fallen further by 2004, to 16 percent. In line with plans to increase this share to one-third by 2010, MARDI's 2002 training budget was set at 4 million current ringgit. One million ringgit was allocated to in-service training for all researchers, especially in new areas where MARDI's capacity is insufficient, while the remainder was allocated to long- and short-term postgraduate training for research staff. These activities are directly funded through MARDI's annual operating budget (provided by the Malaysian Treasury). Staff are also eligible for scholarships provided through the Public Services Department and other external sources. Under these initiatives, 22 of MARDI's researchers received PhD degrees and 10 researchers received MSc degrees in 2004 (of these, 17 were trained locally and 15 were trained in the United Kingdom). New recruits are eligible for postgraduate training after one to three years of service.

During the 1980s, the relative trend of PhD-qualified researchers varied widely at the other 12 public agencies . (Figure 4). MPOB and Sabah's Department of Agriculture, for example, saw an increase of more than one quarter in its share of doctorate holders while FRIM's share increased by 21 percent during this period. In the 1990s, however, the relative shares of researchers holding PhD, MSc, and BSc degrees more or less stabilized at most of these 12 agencies. The qualifications of agricultural research staff at Malaysia's higher-education agencies developed quite differently. While the average share of researchers trained to the postgraduate level remained stable at around 94 percent throughout 1981–2002, the average share of researchers with PhD degrees grew progressively, from 45 percent in 1981 to 73 percent in 2002.

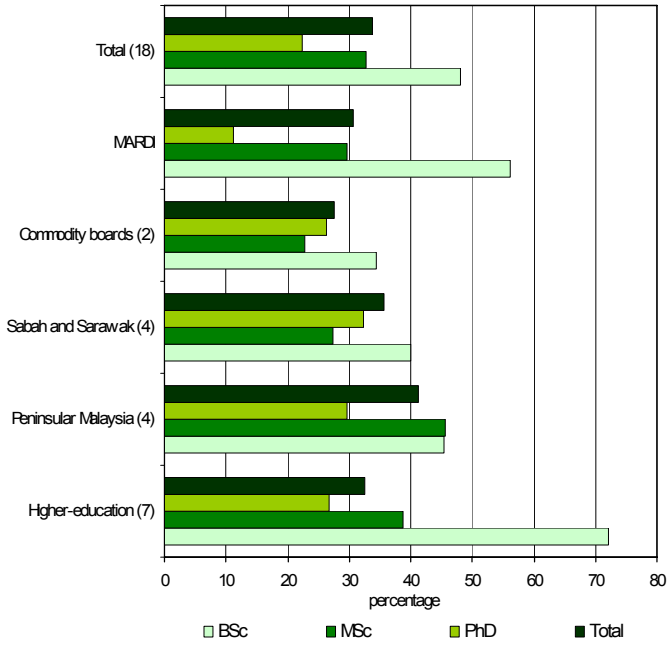
Figure 4—Longterm educational levels of research staff, 1981–2002



Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04).

Despite a rise in the number of women pursuing scientific careers worldwide, female researchers still tend to be underrepresented in senior scientific and leadership positions (Sheridan 1998). Malaysia is no exception. In 2002, 34 percent of fte researchers in an 18-agency sample were female. In terms of qualifications, women represented 22 percent of researchers with doctorate degrees, 33 percent of those trained to the MSc level, and 48 percent of researchers with BSc degrees (Figure 5). Combined, the four peninsula-based government agencies

Figure 5—Share of female researchers, 2002

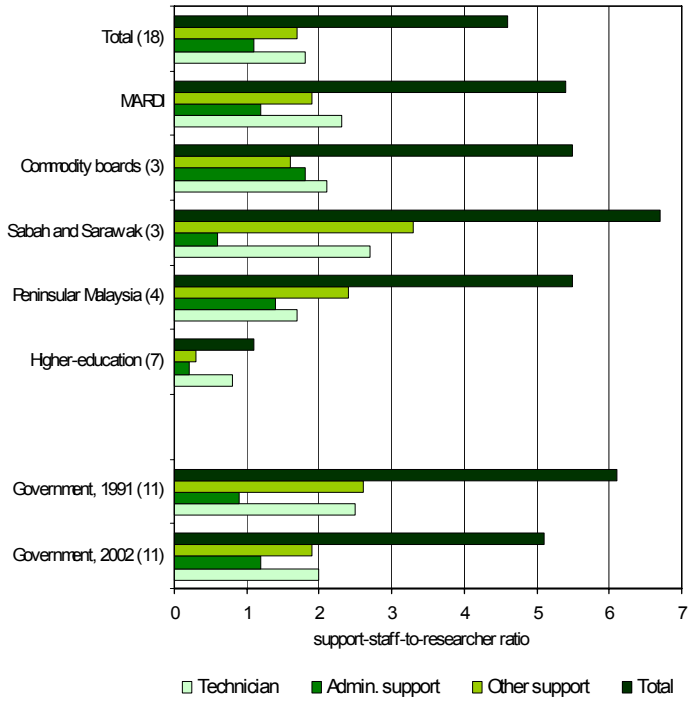


Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003-04).
Note: Figures in parentheses indicate the number of agencies in each category.

employed comparatively more female researchers (41 percent), while the two commodity boards in our sample (MRB and MCB) employed comparatively fewer women (28 percent).

In 2002, for an 18-agency sample for which data were available, the average number of support staff per scientist was 4.6—comprising of 1.8 technicians, 1.1 administrative personnel, and 1.7 other support staff, such as laborers, guards, and drivers (Figure 6). The ratio for the 7 higher-education agencies in the sample (1.1) was much lower than the corresponding ratio for the 11 government agencies (5.1), which is consistent with most developing-country findings. The number of support staff per researcher fell between 1991 and 2002 at MARDI and the four peninsula-based government agencies.

Figure 6—Support-staff-to-researcher ratios, 2002

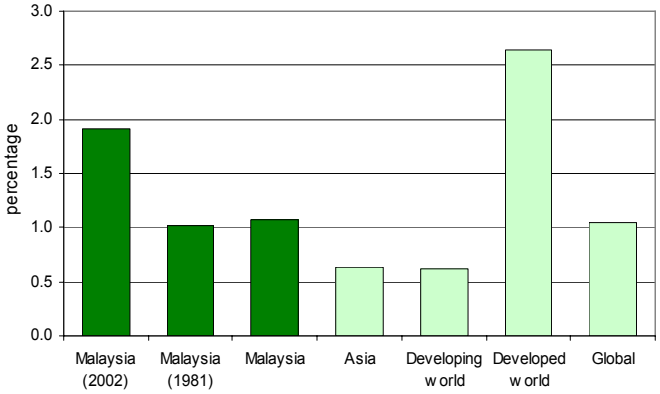


Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003-04).
Note: Figures in parentheses indicate the number of agencies in each category.

Spending

Total public spending as a percent of agricultural output (AgGDP) is a common research investment indicator that helps to place a country's agricultural R&D spending in an internationally comparable context. In 2002, Malaysia invested $1.92 on agricultural research for every $100 of agricultural output, which was roughly 80 percent higher than the corresponding 1995 ratio of 1.07 (Figure 7). The tremendous increase in Malaysia's agricultural research intensity ratio during 1995–2002 is the result of the aforementioned growth in public agricultural research expenditures, combined with a small decline in the country's AgGDP over this period. The 1995 ratio for Malaysia was higher than the reported 1995 average for Asia (0.63) and the developing world (0.62), but lower than the corresponding ratio for the developed world (2.64) (Pardey and Beintema 2001).

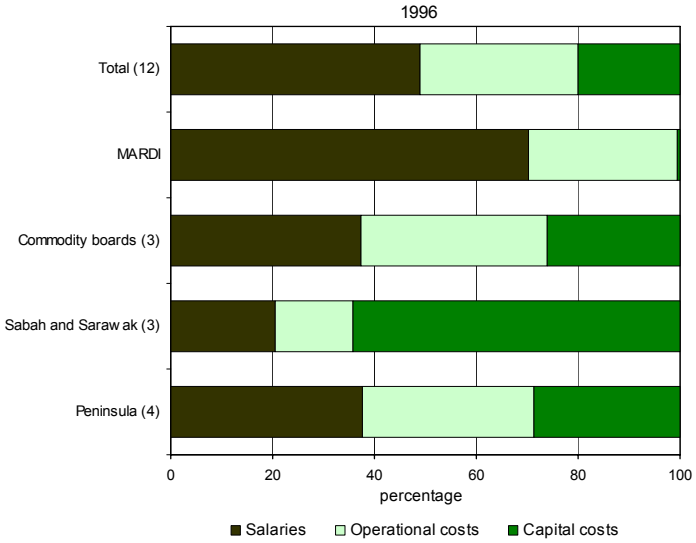
Figure 7—Malaysia's public agricultural research intensity compared regionally and globally

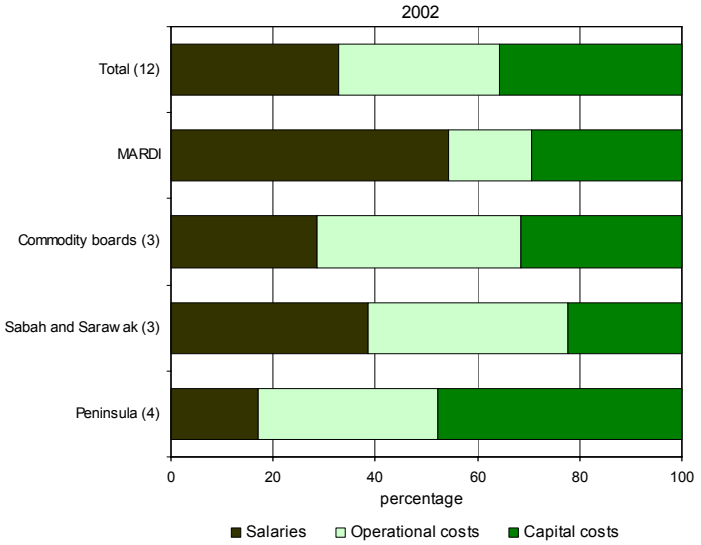


Sources: Malaysia data are compiled from Figure 2; AgGDP data are from World Bank (2005); all other intensity ratios are from Pardey and Beintema (2001). The intensity ratio for Asia excludes China.

Although the 12 government agencies combined spent roughly equal shares on salary, operating, and capital costs, these overall averages masked considerable variations between the agencies (Figure 8). Salaries, for instance, accounted for over half of MARDI's expenditures, capital investments were high at the peninsula-based government agencies (because of high expenditure by FRI and FRIM, as previously mentioned), and capital spending was comparatively low at the Sabah and Sarawak-based public agencies.

Figure 8— Cost-category shares in government agencies' expenditures, 1996 and 2002

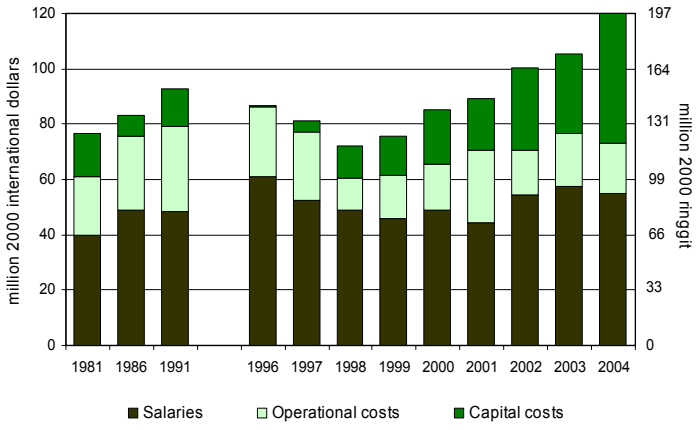




Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04).
Note: Figures in parentheses indicate the number of agencies in each category.

At MARDI, salaries fluctuated as a share of total expenses, from 70 percent in 1996, down to 46 percent in 2004 (Figure 9). This reflects an overall drop in MARDI's researcher numbers during 1996-2001, combined with a strong increase in its capital investments. Since recruitment restrictions were lifted in 2001, staffing numbers, and hence expenditures, have begun to rebound. MARDI's annual operating costs followed an erratic trend during 1996-2004, ranging from $12 to $26 million in constant prices. The institute's operating budget was significantly cut back in 1998–2000 in response to the economic recession of 1997–98. While capital expenditures were also low following the recession, they rose overall, from an unusually low 1 percent in 1996—due to the late disbursement of funding in the first year of the Seventh Malaysia Plan—to 39 percent 2004. This post-recession growth can be explained by the creation of new divisions focusing on high-end research activities, especially biotechnology and strategic research, necessitating the construction of new laboratories and the acquisition of new equipment. This is reflected in the substantial increase in capital spending to $47 million in 2004.

Figure 9—Cost category shares in MARDI's expenditures, 1981–2004



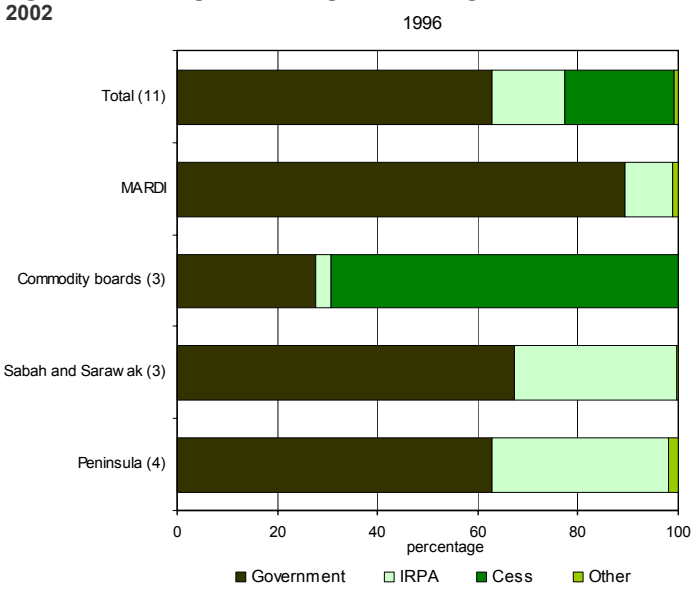
Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04).

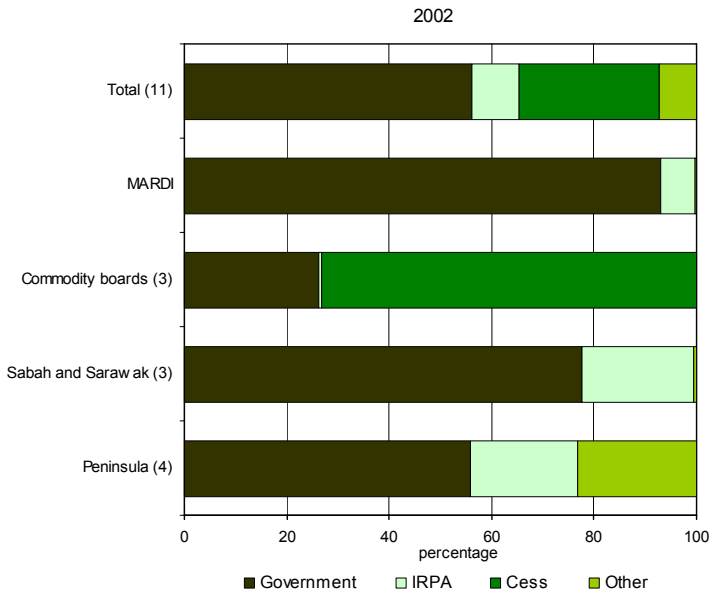
FINANCING PUBLIC AGRICULTURAL R&D

Over the past decade, funding for agricultural research in Malaysia was generated through a number of sources, principally general appropriations from the national government, competitive research grants under the IRPA program—an initiative of the Ministry of Science, Technology, and Innovation (MOSTI)—and cess revenues levied on oil palm and rubber exports. In 2002, direct government appropriations constituted close to 60 percent of the combined agricultural R&D budgets of the 11 government agencies in our sample. Cess revenues generated 25 percent of the funding, the IRPA program contributed 9 percent, and the remaining 6 percent was derived from foreign donors, public and private enterprises, and other sources (Figure 10). MARDI is unique in that nearly 100 percent of its funding is provided by the Malaysian government, either through direct allocations or through IRPA. In contrast (and not surprisingly given their structure), MPOB and MRB are the least dependent on government funding. The four peninsula-based public agencies have gradually increased their shares of nongovernment funding, from just 1 percent in 1996, to 25 percent in 2002. Compared with other developing countries, bilateral and multilateral donor funding played only a marginal role in agricultural R&D in Malaysia.

Government funding to MARDI falls into three categories: an operating budget which includes the salary component (73 percent in 2004), a development budget intended for infrastructure and capital items (buildings, laboratories, equipment, and other facilities) (21 percent in 2004), and the IRPA budget which is solely meant for actual R&D expenditures (6 percent in 2004). Since 2000, certain R&D expenditures are also paid out of the development budget to cater mainly for those research activities that cannot be supported by IRPA funds. This includes so-called maintenance research (such as germplasm collection, maintenance of experimental farms, etc.) that needs to be carried out routinely, but that does not fit into the priority research areas as stipulated under IRPA. Limited financial support to MARDI is also provided by the private sector and international donor agencies. However, these funds were rather insignificant in 2002 (0.4 percent).

Figure 10—Funding sources of government agencies, 1996 and 2002





Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04).
Note: Figures in parentheses indicate the number of agencies in each category.

Intensification of Research Priority Areas (IRPA) Program

IRPA was launched in 1988 with the purpose of enhancing both agricultural and nonagricultural research and development activities in areas of socioeconomic potential for Malaysia (MASTIC 2005). The program was essentially introduced to fund projects of high national priority that represent important commercial value and fulfill the critical needs of the private sector. Increasing collaborative linkages among research agencies and between the public and the private sectors was another goal. To the end, the vast majority of IRPA funds are allocated to activities that enhance commercialization and involve collaboration. Certain funds have also been made available for research activities directed toward knowledge building, with a view to developing future research capacity.

Prior to approval, research proposals are thoroughly screened by various technical committees established by MOSTI. As of 2000, prospective research projects are classified as experimental applied research (EA), prioritized research (PR), or strategic research (SR). EA projects are geared toward generating institutional capacity and knowledge building, but they should also have certain commercial potential and must be completed within three years. PR projects focus on immediate national needs, while SR projects focus on Malaysia's future competitiveness in socioeconomic and environmental fields or on new scientific breakthroughs. Both PR and SR projects must be multi-institutional and multidisciplinary, include private-sector linkages, have commercial potential, and not exceed a five-year duration.

All government and higher-education agencies are eligible for IRPA grants. Private-sector agencies have also become eligible in recent years but only in direct cooperation with the public sector. Grants are to be used only for direct research project expenses, including compensation for contract personnel (but not for permanent staff). The amount of the grant is determined by MOSTI based on the review of the proposal and the proposed project budget. Since its introduction, IRPA had disbursed 2.8 billion current ringgit in project funding.

Although total IRPA funding has increased over time, the allocation of funds to the agricultural sector has gradually declined—from about 38 percent in 1988 to 20 percent in 2003—in favor of manufacturing and other strategic research areas (MASTIC 2004). The share of IRPA revenues as a percentage of total funding for Malaysia's public agricultural R&D agencies also declined throughout 1996-2002 (Figure 11a).

Cess Revenues for Export Crops

MPOB and MRB are largely financed through cess revenues, as previously discussed. The export of crude palm oil is subject to a cess of 7–11 current ringgit per metric ton depending on the selling price,[9] while rubber and latex exports are subject to a cess of 13.77 current ringgit per metric ton, 3.85 current ringgit of which is allocated to research (Treasury of Malaysia 2004). These revenues constituted 86 percent of MPOB's funding in 1996, and 61 percent in 1997 (falling world oil palm prices reduced gross cess revenues, requiring the national government to contribute the balance of MPOB's budget). From 1998 to 2002, however, MPOB's funding was almost entirely derived from the cess (Figure 11b). Given the decreasing role of rubber in the country's economy since 1996, the share of MRB's budget funded through the rubber cess fell from 50 percent in 1996 to 38 percent in 2002. A similar mechanism has not been pursued for MCB because sluggish world market prices have dampened cocoa production levels in Malaysia.

Pam oil and rubber cess collection is very well established. One reason for the success of these commodity taxes is that the private sector is directly involved in the research programs of the commodity boards—the majority of the board members at the commodity boards being representatives from large plantations or private smallholders (Fuglie 2001).

Figure 11a—Share of IRPA revenues in total funding, 1996–2002

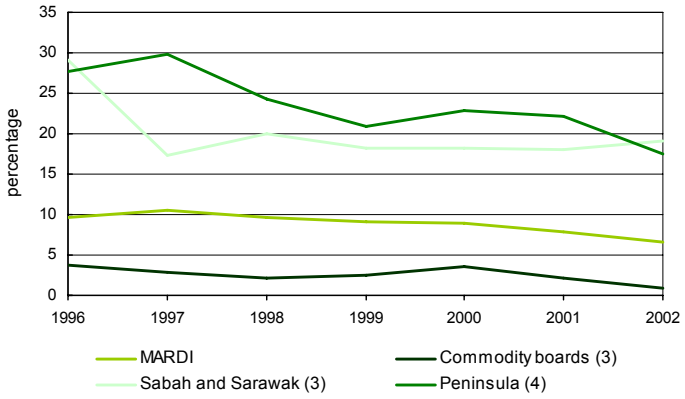
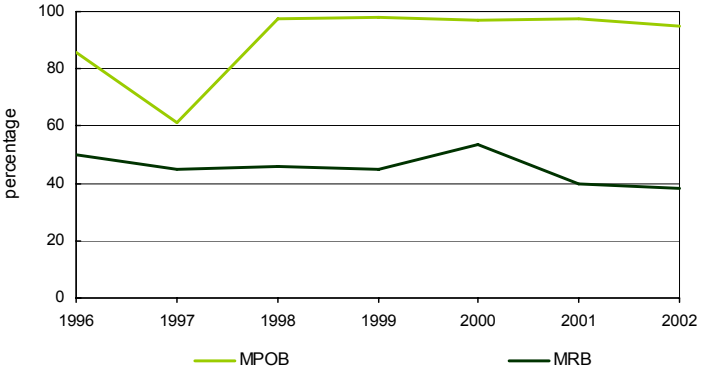


Figure 11b—Share of cess revenues in MPOB and MRB's total funding, 1996–2002



Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003-04).
Note: Figures in parentheses indicate the number of agencies in each category.

PRIVATE AGRICULTURAL R&D

Though the private sector is responsible for the vast majority of scientific research conducted in Malaysia's manufacturing sector, it undertakes limited research in the agricultural sector. We identified 16 private agencies active in agricultural research in Malaysia. Some of these companies were reluctant to provide information on their financial and human resources, but their research activities were reported to be limited or nonexistent. Based on the sample agencies for which data were available, we attributed 8 percent of the country's total agricultural research staff and 5 percent of its agricultural R&D spending to the private sector. Scaling up the total to compensate for the omitted agencies would increase the private-sector share of total agricultural research expenditures to about 6 percent in 2002.[10]

The extent to which some of the agencies in our sample can be classified as "private" requires some qualification. Many of the agencies are large government-linked companies—in particular, the plantation companies. The Malaysian government has a say in the management of these companies (including the appointment of their respective CEOs) through the shares owned by the National Equity Authority, a government corporation. Other private-sector agencies in our sample represent subsidiary companies of government agencies, such as Felda Agriculture Services Sdn Bhd (FAS).

Total agricultural research spending for the 16-agency sample rose from $17 million in 1996 to $20 million in 2002 (3.0 percent per year). Golden Hope Research Sdn. Bhd. (GHRSB) was responsible for almost 30 percent of total private R&D investments in 2002, followed by FAS, at 19 percent; Applied Agricultural Research Sdn Bhd (AAR), at 15 percent; and United Plantation Berhad (UPB) at 13 percent. The remaining 12 enterprises each accounted for private-sector expenditure shares of 4 percent or less. GHRSB, which is a subsidiary of Golden Hope Plantations Berhad, employed 28 fte researchers in 2002, and 37 fte researchers in 2003. GHRSB's research focuses predominantly on palm oil, but research is also conducted on rubber, fruit, aquaculture, agroforestry, and herbs. Specific themes include plant breeding and protection, biotechnology, integrated cropping systems, and water management. GHRSB has three research stations located in Selangor, Sarawak, and Sabah.

FAS, privatized in 1996, aims to improve crop yield (particularly for oil palm) through improved plant material, agronomic practices, pest management, and field management, emphasizing sustainable production methods. In 2002, FAS employed 23 fte researchers. AAR focuses primarily on oil palm genetic improvement, agronomic practices, and pest and disease control. In 2002 it employed 16 fte researchers. The remaining 15 private-sector agencies conducted only limited agricultural research, each employing 4 or fewer fte researchers in 2002.

During 1996–2002, nearly all private-sector research investments in Malaysia were in plantation crops (oil palm, coconut palm, sugarcane, and rubber). Oil palm accounted for over three-quarters of the private research conducted in 2002 (71 fte researchers). Researchers at 7 of the 16 private agencies in our sample spent at least 70 percent of their time on oil palm research in collaboration with MPOB. MPOB mainly conducts basic and pre-technology research, while the plantation companies focus on applied research, including breeding, soil and fertility management, waste management, pest and disease control, and mechanization. Representatives of these plantation companies also hold positions on MPOB's Board of Directors and Technical Council. MPOB also collects, maintains, and evaluates oil palm germplasm from around the world, which the plantation companies can access for promising new traits (Fuglie 2001).

Two other plantation crops, coconut palm and sugarcane, each accounted for 5 percent of Malaysia's private-sector R&D investments. The Agronomy/R&D Unit of Island & Peninsular Berhard (ISPLN) is dominant in the coconut palm field, while Kilang Gula Felda Perlis Sdn Bhd (KGFP) is the primary Malaysian company involved in sugarcane research. These companies employed 3 fte researchers each in 2002.

The future of private-sector agricultural R&D in Malaysia looks encouraging. The current administration has identified agriculture as one of three engines for growth and is backing its strategy with a number of development policies and programs, including mechanisms to promote R&D. Among these is the establishment the Malaysia Technology Development Corporation (MTDC), a government agency promoting agricultural R&D (MASTIC 2005). This corporation provides financial and professional assistance for the commercialization of R&D findings and facilitates technology transfer. In addition, the government provides grants and funding for R&D conducted by the private sector. As mentioned earlier, the private sector is now eligible for IRPA funding for R&D activities conducted in collaboration with the public sector. Similarly, the Industry Research and Development Grant Scheme (IGS) promotes private-sector research activities and private- and public-sector collaboration. The aim of this scheme is to reduce the gap between research work and commercialization. The key technology areas that are given priority are the ones that support the Second Industrial Master Plan 1996-2005 (IMP2). All approved R&D proposals must be undertaken in Malaysia. The maximum duration of the grant is three years.

Another government initiative to increase private-sector involvement in agricultural research is the Investment and Capital Tax Allowance, which offers three major incentives through the Pioneer Status Program, an investment tax allowance, and a double tax deduction. Through the Pioneer Status Program, the government offers a 100 percent tax exemption on statutory income for five years. The government also offers companies that provide R&D services in Malaysia to its related company or any other company an Investment Allowance of 100 percent on the qualifying capital expenditure incurred within 10 years. Moreover, such companies can also apply for a double tax deduction on noncapital expenditures for research undertaken by approved research institutes. This has encouraged companies to outsource their research to Malaysian agencies.

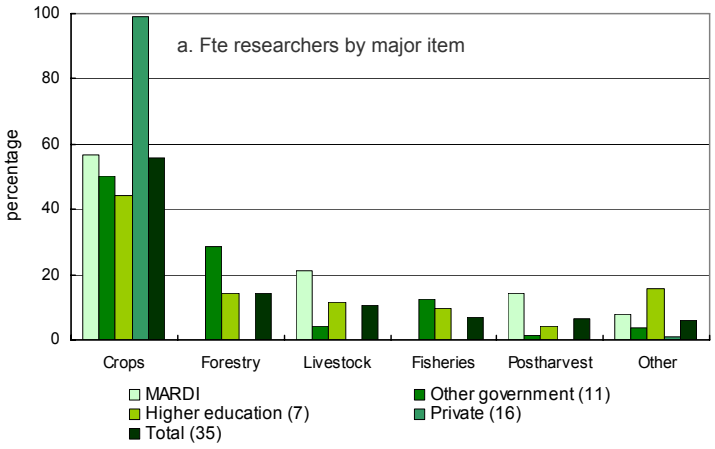
RESEARCH ORIENTATION

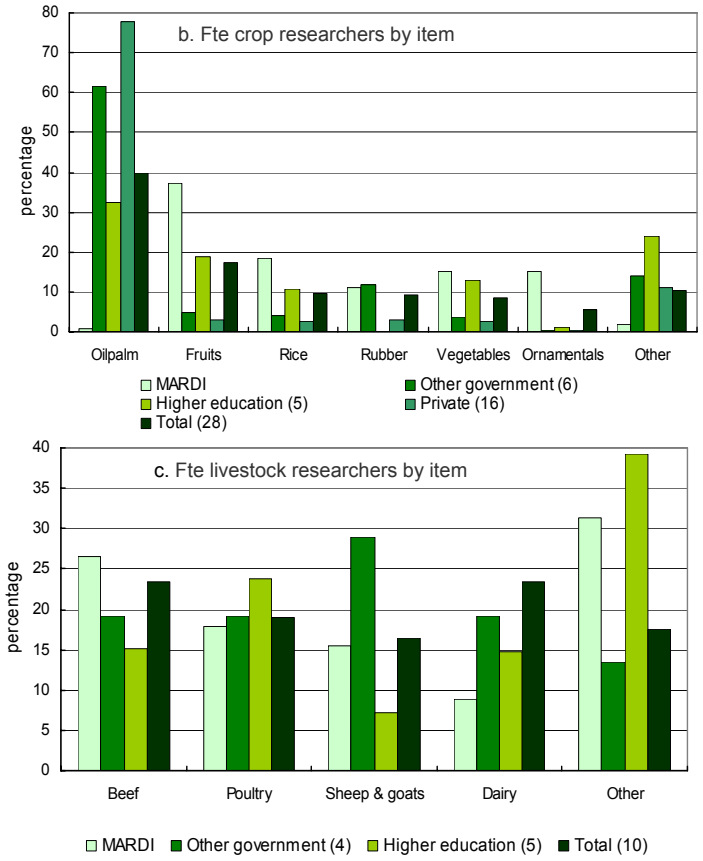
Commodity Focus

The allocation of resources among various lines of research is a significant policy decision, and so detailed information was collected on the number of fte researchers working in specific commodity and thematic areas.

In 2002, more than half of the 1,201 fte researchers of our 35-agency sample conducted crop research. Forestry research accounted for 14 percent of the total, livestock research for 11 percent, and fisheries and postharvest research for 7 percent each (Figure 12a). Research staff at MARDI spent relatively more time on crop, livestock, and postharvest research than their counterparts at the other government and higher-education agencies. Given the strong private-sector focus on oil palm, private researchers concentrated almost exclusively on crops (99 percent). Oil palm accounted for 40 percent of the research conducted on crops, fruits for 17 percent, rice for 10 percent, rubber for 9 percent, vegetables for 8 percent, and ornamentals for 6 percent (Figure 12b). Oil palm research also accounted for nearly 80 percent of the researchers at the private-sector agencies, more than 60 percent of researchers at the government agencies (other than MARDI, which has a food crop and livestock research mandate), and close to one-third of the researchers at the higher-education agencies. Most livestock researchers focused on beef and dairy (24 percent each). Other livestock themes included poultry (19 percent) and sheep and goats (16 percent) (Figure 12c). Two-thirds of Malaysia's livestock research is carried out by MARDI.

Figure 12—Commodity Focus, 2002



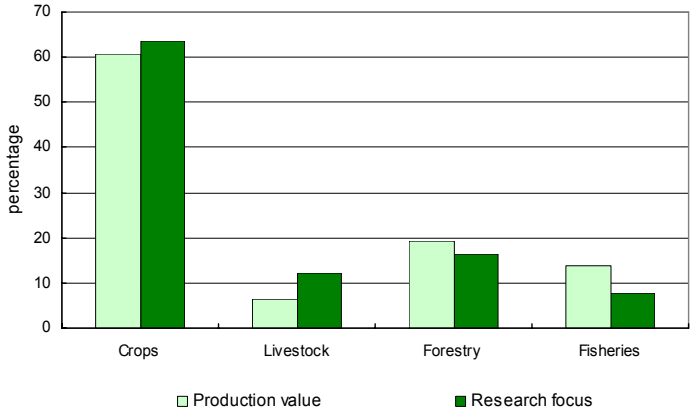


Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04).
Notes: Figures in parentheses indicate the number of agencies in each category. Figure 12b only includes agencies involved in crop research; Figure 12c only includes agencies involved in livestock research.

The congruency or parity model is a commonly used method of assessing the allocation of research resources. This usually involves allocating funds (or, in this instance research personnel) among research areas in proportion to their corresponding contribution to the value of agricultural production. For example, if the value of rice output were twice that of maize, then congruence would be achieved if research on rice were to receive twice as much funding (or, say, employ twice as many scientists) as maize. The model assumes that an additional dollar spent on research would yield a higher return if spent in areas with a relatively low ratio of research funding to output value, therefore funds should flow toward programs with relatively low research intensities and from those with high research intensities. If research spending or scientist shares were congruent with the corresponding value of output for a particular commodity, then the congruency ratio for that commodity—measuring the commodity share of researchers to the corresponding share of output—would be equal to 1.0.[11]

Figure 13 shows the shares of crops, livestock, fisheries, and forestry in gross value of agricultural production with the corresponding share of research staff in these areas. In 2002, 64 percent of the researchers in our subsample conducted crop research—slightly higher than the share of crops in the total value of production (61 percent). The share of livestock researchers was almost double its share in total production value, resulting in a congruency ratio of 1.9. The congruency ratios for fisheries and forestry were lower than 1.0 (Government of Malaysia 2003).

Figure 13— Congruence between agricultural R&D and production value, 2002-03



Sources: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04). Production values are from Government of Malaysia (2003).
Notes: Postharvest and other research themes are not included. Production values are for 2003, research focus is for 2002.

Thematic Focus

In 2002, of the 1,013 fte researchers in a 34-agency sample 17 percent were working on agronomic themes; another 17 percent pursued crop genetic improvement, 10 percent focused on natural resources research, 9 percent were involved in livestock management, and 8 percent were employed in crop pest and disease control (Table 2). The remainder of the researchers focused on other crop and livestock themes, while only a small portion worked on soils, postharvest, and water research. The focus of the 11 government agencies in our sample was largely on crops (40 percent) and natural resource themes (21 percent). Postharvest research and food safety were relatively more important research themes at the higher-education agencies than at the government agencies, accounting for 11 and 7 percent of time spent on research at the higher-education agencies in 2002. Close to 90 percent of research staff at the 16 private-sector agencies focused on crop-related themes, with crop genetic improvement accounting for 43 percent, and agronomic themes accounting for 30 percent of private-sector researchers' time.

Table 2—Thematic focus, 2002

	Numbers of researchers		Shares	
	Government (11)	Higher education (7)	Government (11)	Higher education (7)
	(*in fte's*)		(*percent*)	
Crop genetic improvement	113.0	16.5	14.6	11.4
Crop pest and disease control	61.7	10.7	7.9	7.4
Other crop	138.7	13.6	17.9	9.4
Livestock genetic improvement	26.5	12.5	3.4	8.6
Livestock pest and disease control	19.8	12.5	2.6	8.6
Other livestock	103.7	4.8	13.4	3.3
Soil	44.0	10.9	5.7	7.5
Water	21.7	5.7	2.8	3.9
Other natural resources	95.3	6.7	12.3	4.6
Postharvest	32.1	15.6	4.1	10.8
Other	120.0	35.6	15.5	24.6
Total	**776.3**	**144.9**	**100.0**	**100.0**

Source: Compiled by authors from ASTI survey data (IFPRI–MARDI 2003–04).
Notes: Figures in parentheses indicate the number of agencies in each category. Government (11) excludes MPOB; higher education (7) excludes the School of Biological Sciences of the Universiti Sains Malaysia.

CONCLUSION

Although MASTIC reported that agricultural R&D accounted for only 4 percent of Malaysia's public and private research spending in 2002 (MASTIC 2004), the sector experienced strong growth in terms of human resources and spending from 1981 until 2002. Total fte agricultural researchers rose steadily during this period, and the country's public agricultural R&D expenditures nearly tripled over this time frame, reaching $384 million in constant 2000 prices. Agencies focusing on export plantation crops in particular reported significant increases in their total spending levels. Research spending and staffing levels at MARDI, however, showed little growth but are expected to increase in the coming years, given the institute's aggressive recruitment drive in recent years, especially in new strategic R&D areas such as biotechnology.

The agricultural sector has been identified by the Malaysian government as one of three engines of growth for economic development. Agricultural R&D agencies—in both the public and private sectors—are expected to play a dominant role in achieving this growth. Financial support by the national government to public agricultural research is therefore expected to continue in the years to come. The government has introduced various incentives to stimulate private-sector involvement in R&D, and particularly to foster cooperation between public and private agencies.

NOTES

1. The authors are grateful to numerous colleagues in Malaysia for their time and assistance with the data collection, and thank Datuk Abdul Hamid Syawal, Fadzilah Ahmad Din, Haji Khairudin Hashim, Keith Fuglie, Tan Sri Datuk Dr Yusof Basiron, and Tengku Mohd Ariff Tengku Ahmad, for their useful comments on drafts of this brief.
2. The data in this section are based on direct funding of R&D projects; they do not include salaries, operating costs, or capital expenditures.
3. The 36-agency sample comprises the following agencies.
   - Twelve government agencies/units: the Malaysian Agriculture Research and Development Institute (MARDI); the Veterinary Research Institute (VRI); the Fisheries Research Institute (FRI); the Forestry Research Institute Malaysia (FRIM); the Malaysian Rubber Board (MRB); the Malaysian Cocoa Board (MCB); the Malaysia Palm Oil Board (MPOB); the Malaysian Institute for Nuclear Technology Research (MINT); the Department of Agriculture, Sarawak (DOA Sarawak); the Forest Research Centre, Sarawak (FRC Sarawak); the Fisheries Research Institute, Sarawak (FRI Sarawak); and the Department of Agriculture, Sabah (DOA Sabah).
   - Eight higher-education agencies: the Faculty of Agriculture, the Faculty of Veterinary Medicine, the Faculty of Forestry, and the Faculty of Food Sciences and Biotechnology, all under the Universiti Putra Malaysia (UPM); the Faculty of Science and Technology of the Universiti Kebangsaan Malaysia (UKM); the Faculty of Resource Sciences and Technology of the Universiti Malaysia Sarawak (UNIMAS); the School of Biological Sciences (SBS) of the Universiti Sains Malaysia (USM); and the Faculty of Agrotechnology and Food Science of the Kolej Universiti Sains dan Teknologi Malaysia (KUSTEM).
   - Sixteen private enterprises: Agriculture Chemicals Sdn Bhd (AgChem); United Plantation Berhad (UPB); BASF; Golden Hope Research Sdn. Bhd. (GHRSB); Hextar Chemicals (HChem); CCM Fertilizers (CCMF); Emdek Sendirian Berhad (EMDEK); Applied Agricultural Research (AAR); Sime Aerogreen Technology (SAT); Espek Research and Advisory Services (ESPEK); Ancom Corp Sdn Bhd (ANCOM); Dow AgroScience Sdn Bhd (DOW); Felda Agriculture Services Sdn Bhd (FELDA); Gula Padang Terap Plantation Sdn Bhd (GPTKD); the Agronomy/R&D Unit of Island and Peninsular Berhard (ISPLN); and Kilang Gula Felda Perlis Sdn Bhd (KGFP).

   This sample excludes two higher-education agencies (the Faculty of Agrotechnology and Food Science of KUSTEM and the Faculty of Resource Science and Technology of UNIMAS) and a few private-sector agencies for which data were unobtainable.
4. Unless otherwise stated, data on research expenditures are reported in 2000 Malaysian ringgit or 2000 international dollars.
5. These units are the Technology Promotion and Development Center, the Technical Services Center, the Station Management Center, the Business Development Unit, and the Planting Material, Seeds and Livestock Breed Production Unit.
6. A fourth commodity board, the Malaysian Pineapple Industry Board (MPIB), was established in 1992. MPIB is not, however, involved in pineapple research.
7. The two omitted agencies reportedly conduct minimal agricultural research; with their inclusion, these totals would be slightly, though not substantially, higher.
8. Total cocoa production is projected to fall by 1.7 percent annually until 2010 because farmers are increasingly shifting from the production of cocoa to the production of more lucrative crops like palm oil (FAO 2003).
9. The cess is 7 ringgit per metric ton when the price is less than 1,000 current ringgit per metric ton, and 11 current ringgit per metric ton when the price is 1,000 current ringgit per metric ton or higher.
10. A total of 41 private-sector agencies were identified at the onset of this study, largely based on Fuglie (2001). Sixteen agencies (some conducting only very limited R&D) responded favorably to our request for information; five agencies indicated they no longer conduct agricultural R&D; and the remaining agencies were not responsive, though their research efforts are reported to be limited or nonexistent. Given that salary expenditures were omitted from public spending data in Fuglie (2001), the present study reports vastly different private-sector agricultural R&D spending shares than Fuglie (2001).
11. It is important to note, as described in Alston et al. (1998), that the model overlooks key factors affecting the payoff to R&D, such as the differences in probability of research success, likely adoption rates, and the likely extent of research-induced productivity gains. In addition, the model does not account for technology spill-ins from other countries, or differences in costs per scientists among different R&D areas. So, while the congruence rule is both useful for allocating resources and a distinct improvement over precedence and some other shortcut methods, ratios that differ from 1.0 are not necessarily a cause for concern.

METHODOLOGY

- Most of the data in this brief are taken from unpublished surveys (IFPRI and MARDI 2003-04).
- The data were compiled using internationally accepted statistical procedures and definitions developed by the OECD and UNESCO for compiling R&D statistics (OECD 1994; UNESCO 1984). The authors grouped estimates using three major institutional categories—government agencies, higher-education agencies, and business enterprises, the latter comprising the subcategories private enterprises and nonprofit institutions. The researchers defined public agricultural research to include government agencies, higher-education agencies, and nonprofit institutions, thereby excluding private enterprises. Private research includes research performed by private-for-profit enterprises developing pre, on, and postfarm technologies related to agriculture.
- Agricultural research includes crops, livestock, forestry, and fisheries research plus agriculturally related natural resources research, all measured on a performer basis.
- Financial data were converted to 2000 international dollars by deflating current local currency units with a Malaysian GDP deflator of base year 2000 and then converting to U.S. dollars with a 2000 purchasing power parity (PPP) index, both taken from World Bank (2005). PPP's are synthetic exchange rates used to reflect the purchasing power of currencies, typically comparing prices among a broader range of goods and services than conventional exchange rates.
- Annual growth rates were calculated using the least-squares regression method, which takes into account all observations in a period. This results in growth rates that reflect general trends that are not disproportionately influenced by exceptional values, especially at the end point of the period.

See the ASTI website (http://www.ASTI.cgiar.org) for more details on methodology.

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