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Green Devolution

Taiwanese Vegetable Science, Nutrition, and the Developing World, 1969–1989

Because the Taiwan story is largely a success story, I believe that professionals in the development business should spend time studying the development history of the island

—BRUCE H. BILLINGS

I get the feeling that if it were not for the Geo-political factors, the going would not be quite so rough.

—ROBERT F. CHANDLER

INTRODUCTION

In 1968, USAID Director William Gaud coined the term *Green Revolution* to refer to the increased global production of staple food crops (maize, wheat, rice) through high-yielding varieties that responded well to intensive methods of cultivation, namely increased inputs of chemical fertilizers and pesticides.[1] Norman Borlaug, the plant breeder who in the 1940s pioneered high-yield, semi-dwarf wheat in Mexico, won a Nobel Peace Prize two years later, in 1970, in recognition of his contributions to agricultural science. The increases in production made possible through high-yield varieties and fertilizers proved a paradigm shift in development practice. Previously, fears of a Malthusian trap, referring to Thomas Robert Malthus's thesis that population growth would always outstrip food supply and thus strain developing economies, preoccupied international development planners and led to detrimental state-led and international NGO initiatives in population control.[2] The Green Revolution offered states a different solution to their Malthusian concerns by increasing food production beyond the rate of population growth.

At the same time, Green Revolution reliance on chemical fertilizers and pesticides further entrenched the industrialization of agriculture across the world, and with it, new global environmental dangers, including chemical runoff and pollution. The Green Revolution paradigm shift to monocultures—single-crop agriculture to the exclusion of crop variety—created dependencies on improved seeds. In the decades that followed, Global-South states turned away from the development and production of improved seeds and instead ceded this to private corporations located in the Global North, which then patented those seeds and monopolized seed markets. This monopoly in effect locked farmers into a dependent relationship with large agribusinesses. Improved crops emerging from the Green Revolution focused on production above all else. As a result, they were often of lower quality and inferior taste, which limited market demand and reduced their utility to farmers.[3] Despite all these significant problems, during the 1970s, production was king, and the Green Revolution was seen as the key to a promising future of agricultural science and international development. The ultimate consequences of Green Revolution methods were not yet clear.

Equally important was Gaud's contrast of the Green Revolution to what he perceived as "Red Revolution," referring to the Soviet Union, or "White Revolution," referring to Iran. The Green Revolution offered an alternative model based on technology and science that Gaud likened to the Industrial Revolution.[4] As critical scholars have argued, the Green Revolution should be seen instead as a US project to combat the influence of Communism by co-opting agricultural science and industrialized agriculture in the ongoing global Cold War.[5]

For Taiwan, the popularization of agricultural science provided a political opportunity amid an existential crisis. In 1971, UN General Assembly Resolution 2758 permanently banished representatives from the Republic of China from the United Nations. While ROC dictator Chiang Kai-shek bristled at the indignity of being replaced by the Communist regime of the PRC for a few years before he died in 1975, the geopolitical ramifications of the ROC's ouster would be far more disastrous for Taiwan in the long term. For almost a decade, Taiwan had been engaging in agricultural development on a bilateral basis, showcasing its agricultural expertise in the fields of Asia and Africa and its growth curves in academic conferences in an effort to preserve its UN seat. UN Resolution 2758 precipitated the cessation of formal diplomatic relations with many of these countries. With the increasing visibility of agricultural science and its potential to combat the global issues of poverty and hunger, Taiwanese policymakers and scientists seized an opportunity to gain a greater platform for Taiwan's agricultural success and in turn to resolve a political situation that threatened to marginalize Taiwan.

Vegetables and nutrition offered that means for Taiwan to seek geopolitical allies in the midst of its ouster from the United Nations. Whereas the Vanguard missions of the 1960s that sent Taiwanese agricultural technicians to Southeast Asia and Africa emphasized Taiwan's low-capital, practical solutions for other developing nations, the international agricultural research centers of the 1970s symbolized Taiwan's turn to vitamins, proteins, and caloric intake within a discourse and imagination of scientific modernity. This continues a narrative of the co-option of science and technology for Taiwan's political ends. But unlike earlier efforts in the 1960s, by the 1970s, Taiwan's marginalization following UN Resolution 2758 is a discontinuity that marks the decline of Taiwan's international agrarian project.

This chapter explores the construction, politics, and consequences of Taiwanese agricultural science amid global attention to nutrition and industrialized agriculture preceding and following the Republic of China's ouster from the United Nations in 1971. It examines several institutions, the Food and Fertilizer Technology Center (FFTC, 糧食肥料技術中心, Liangshi Feiliao Jishu Zhongxin), founded in 1971, and the Asian Vegetable Research and Development Center (AVRDC, 亞洲蔬菜研究發展中心, Yazhou Shucai Yanjiu Fazhan Zhongxin), founded in 1972. How did Taiwanese scientists seek to leverage Taiwan's expertise in plant breeding, plant physiology, soil science, entomology, chemical fertilizer, and food industry via global networks? Organized through and often funded by the US government and US-based philanthropic organizations like the Rockefeller and Ford Foundations, these multilateral networks connected Taiwan with other American Cold War allies, such as Japan, South Korea, the Philippines, and Thailand for the purpose of regional and global development. For Taiwan, these scientific institutions represented another means to internationalize through an ostensibly Taiwanese-specific approach to agricultural science, which simultaneously served to advance its diplomatic goals. Taiwanese planners turned once again to science, this time as a way to regain a semblance of regional and global power following its UN ouster.

The AVRDC and FFTC also represented a turn to more "high-modernist" science and technology. The marketing success of the Green Revolution made science and technology one of the predominant trends in international development in the 1970s, surpassing and eclipsing, for example, community development and land reform.[6] In contrast with "low-modernist" approaches of organizing farmers' associations and disseminating knowledge to the lowest rungs of society, high-modernist science championed the scientific advances resulting from selective breeding in laboratories and experiment fields and industrial scale production. The FFTC emphasized intensive chemical fertilizers. The AVRDC focused on the other part of the Green Revolution formula—seeds. The idea that seeds selected through experimentation could save millions of lives appealed to popular opinion, at a time when humans were traveling into outer space and possibilities for modern science seemed limitless.

The founding of the FFTC and the AVRDC coincided with a growing international concern for food and food politics. The FFTC and the Food Industry Research and Development Institute, a private research center in Taiwan headed by Ma Baozhi after his return from the University of Liberia, emerged as development shifted away from just resolving basic hunger needs to a focus on the food industry as an important economic sector and food nutrition as a symbol of social progress and economic development. The AVRDC represented a similar effort in international development by focusing on Taiwan's tropical and subtropical climate and its multitude of vegetable varieties. In marketing vegetables, as opposed to rice, maize, or wheat that were developed at the beginning of the Green Revolution, the AVRDC represented another shift, from satisfying basic caloric intake to a more diversified view of nutritional science involving vitamins and minerals.

This chapter also serves as a bookend to the narrative of Taiwanese development. It focuses on the global ramifications of Taiwan's domestic agrarian project but with adverse and permanent consequences for the state and society at home. And it ends with a rapid "fall" of Taiwanese development after its dramatic rise in international development in the late 1950s and 1960s. Taiwan's efforts at disseminating its vegetable and nutrition technologies ultimately succumbed to three headwinds. First, nutrition, as embodied by vitamins, minerals, and proteins, did not receive as much attention as the Green Revolution breakthrough in caloric productivity via cereals. Second, international development begin to shift away from state-funded projects during the Cold War and instead to international agencies and private corporations, especially with the growing move toward market-based solutions. Finally, the geopolitical marginalization of Taiwan following its exclusion from the UN doomed Taiwanese-based institutions like the AVRDC and the FFTC to the global margins instead of the global center. Because of Taiwan's non-country status in the UN, the AVRDC and other centers in Taiwan were not included within the Consultative Group for International Agricultural Research (CGIAR), the group that included the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT). In effect, Taiwan was forced out of its privileged position at the global vanguard of agrarian development.

RICE

By the 1970s, nuclear weapons, missions to outer space, family-planning contraception, and medicinal advances captured the attention of both governments and the general public. In agricultural sciences, there was also a proliferation in research and public perception in the post-WWII era. Centers dedicated to specific crops emerged, such as CIMMYT for maize and IRRI for rice. Agricultural scientific research centers were not new to the Cold War era. In the United States, Japan, and China, research centers, experiment stations, and universities working in agricultural science had been collecting, comparing, and selecting higher yielding varieties since the late nineteenth century, driven by state objectives to increase agricultural productivity for greater economic profit.[7] Chapter 3 discussed some of the more specialized research centers that emerged in the postwar era on Taiwan, such as the Plant Protection Center, established in 1960, that brought the basic sciences of studying plant diseases to practical applications that could be field-trailed and disseminated through extension. However, CIMMYT's and IRRI's establishment in the Global South (Mexico and the Philippines, respectively) was novel, revealing a shift in how agricultural science began to become integrated into developmental policies throughout the world.

Taiwan was also involved in this specialization of agricultural science, with greater focus on specific agricultural products and technologies and increasingly globalized networks of cooperation and knowledge exchange. In addition to centers focusing on plant protection (discussed in chapter 3), vegetables, and fertilizer, there were proposals for research and demonstration centers in other aspects of Taiwan's agricultural success, such as irrigation.[8] This shift toward an international outlook coincided with the rise of Operation Vanguard and the Land Reform Training Institute, both of which sought to convey the Taiwan model to a global audience. Whereas centers like the Plant Protection Center were primarily looking inward, toward Taiwan as its primary beneficiary, new centers of the 1970s looked outward, first regionally within Asia and then globally to Africa and Latin America.

Research centers began to look outward as early as the 1950s, particularly to areas that possessed similar climates and environments to Taiwan. In 1958, the Taiwan Agricultural Research Institute (TARI) submitted a grant request to the Rockefeller Foundation for a "Program of Studies on the Causes of Low Yield of Rice in Tropical and Sub-Tropical Regions" and the establishment of an "Insect Identification Center for Southeast Asia." TARI, formerly an agricultural experiment station founded in 1895 by the Japanese colonial government on Taiwan, was reorganized as an agricultural research institute. After the GMD took over Taiwan in 1945, the institute was integrated into the Taiwan provincial government. TARI eventually became responsible for eight experiment stations throughout Taiwan ranging in specialties from cotton to tea, which was typical of experiment stations in order to approximate local growing conditions and crops suited for the different regions of the island.

In the grant request, TARI framed their project in terms of the unique environmental aspects of Taiwan: "The Tropic of Cancer passes through the island, and its climate is such that both the *Japonica* and *Indica* types of rice can be grown there. For this reason, Taiwan is an ideal place to undertake studies of rice, particularly with reference to the comparative environmental requirements of these two types." The proposal continued to list the shortcomings of each type, with *Indica* possessing a higher tolerance for low fertility soil and higher temperatures but a low response to fertilizer, while *Japonica*, a shorter-grained rice that was preferred by the Taiwanese, flourished in more temperate climates and seemed to be limited in tropical ones. It framed its research globally, highlighting their stock of 2,285 rice varieties from all over the world. And it referenced efforts conducted by other international organizations in regional rice research, for example, efforts by the UN Food and Agriculture Organization in producing *Japonica-Indica* crosses to select for high fertilizer response in tropical climates.[9]

TARI was not the only institute to which the Rockefeller Foundation and other organizations were looking. Because rice was a staple crop providing basic sustenance for a great portion of Northeast, East, and Southeast Asia, numerous international development organizations sought to increase rice yields to resolve ongoing malnutrition in Asia. As historian Nick Cullather has argued, staple cereals like rice became an intense focus of development organizations like the Rockefeller Foundation due to a focus on providing sufficient calories, a need that was seen as helping to subvert social tendencies to support Communist movements and regimes.[10] Encouraged by positive results from their efforts to improve maize and wheat in Mexico led by Norman Borlaug, the Rockefeller and Ford Foundations helped found the International Rice Research Institute (IRRI) in the Philippines.[11]

The IRRI drew on a diverse group of scientists from Asia and the United States. Ma Baozhi, the agronomist who had served previously as the dean of the College of Agriculture in National Taiwan University and the head of the Taiwanese crop improvement mission to Vietnam (see chapter 5), was a founding trustee. A number of scientists from Taiwan worked at the IRRI, such as plant geneticist Zhang Deci (張德慈, T. T. Chang) and plant pathologist Ou Shihuang (歐世璜, Ou Shu-huang), who served as divisional head at the request of the Rockefeller Foundation.[12] Shen Zonghan later joined later the board of trustees and oversaw training exchanges and cooperation in rice breeding between Ou Shihuang and the JCRR Plant Industry division. Though many of these elite scientists had trained in the United States, they nonetheless carried experience from their work in their home countries.

Taiwan's contribution to international rice research was not just in human capital. It also provided one of the key scientific innovations in the most famous product of the IRRI and one of the most famous of the Green Revolution: miracle rice. Miracle rice was a moniker given to a specific varietal of rice, IR-8, that emerged from the varietal improvement project of IRRI. IR-8, a semi-dwarf variety of rice, was high yielding, produced more grain per stalk of rice, and was more responsive to chemical fertilizers that were crucial to Green Revolution.[13] IR-8 was crossbred from two cultivars. The first was Peta, a fast growing and responsive variety from Indonesia, but it was a tall breed, meaning it was prone to falling over during typhoons and high winds, submerging the rice grains underwater or exposing it to ground-based rodents and other pests. The other was a cultivar from Taiwan, 'Dee-Geo-Woo-Gen' (低腳烏尖, Dijiao Wujian) or more commonly known by its acronym, DGWG. DGWG possessed the key dwarfing gene *sd1* that allowed IR-8 to resist toppling over (figure 35).[14]

Zhang Deci was one of the three main plant geneticists recognized for working on IR-8, and his familiarity with Taiwanese rice varieties like DGWG helped in the development of IR-8.[15] Zhang, in addition to being a graduate of Nanking University and a student of Shen Zonghan, was a JCRR scientist from the Plant Industry division. As much as IR-8 was celebrated for its technical success and

FIGURE 35. A comparison between IR-8 (*left*) and its two parent varieties: Peta (*middle*), an Indonesian variety that was hardy but tall and thus prone to toppling over; and 'Dee-Geo-Woo-Gen', or DGWG (*right*), the Taiwanese variety that possessed the dwarfing allele to allow for the semi-dwarf characteristic of IR-8. Hargrove and Coffman, "Breeding History."

production figures versus local varieties, it was also the international cooperation in advancing science for different global regions that excited so many development practitioners and scientists. The international backgrounds of the key members of the IR-8 team, consisting of scientists from the United States, Mexico, Colombia, and Taiwan, facilitated knowledge of varietals from all over the globe and allowed for the selection of specific genes that they sought. In Zhang's letter to his mentor, Shen Zonghan, he specifically referenced the precedent set by Taichung No. 1, another semi-dwarfing variety of rice from Taiwan, that had already been adopted and grown in India, thus ostensibly paving the way for easier acceptance of IR-8.[16] Bridging scientific knowledge and technologies across borders, which can be traced back centuries to the acclimatization movement of the nineteenth century that sought non-native species for improvement of local environments, seemed to be the future of agricultural science.

NUTRITION

One of the goals of high-yielding rice was applying scientific principles and mass production to increase raw caloric intake and thus resolve social problems of poverty and malnourishment. Though high-yield varieties emerged in the mid-twentieth century, societal concerns over nutrition were not new. Nutrition as an object of policy and public health concern emerged as early as the nineteenth century in Britain, where alimentation arose as a means to intervene into bodies and regimens of the working poor.[17] Historian Jia-chen Fu has written about Chinese scientists and public health activists in the early twentieth century seizing on soybeans "as a miracle plant with which to build modern economies and healthy nations."[18] These activists argued that the soybean, with its high protein content and myriad vitamins, provided the answer to China's modern and developmental needs. These same discussions occurred in Taiwan as well in the early years after the arrival of the Nationalist regime on the island.

In the early 1950s, the ROC government was still searching for new sources of nutritionally rich and cheap sources of food for both its growing human population and the increasingly important animal livestock industry. Historian Nick Cullather has explored the rise of the calorimeter and calorie counting in early twentieth-century nutrition science in the United States as an evolution toward a rationalized treatment of nutrition. This "'scientific eating' based on 'calorie bookkeeping,'" referring to the careful quantification of daily diets and accounting for caloric intake, influenced how policymakers understood public health.[19] For Taiwan, historian Pin-tsang Tseng has shown how the ROC regime, upon taking over Taiwan after retrocession in 1945, implemented strict rationing due to food shortages during the civil war with the Communists on the mainland. This food-rationing regime altered the ratio of consumed staple foods versus non-staple foods, with the former coming from the increase in rice productivity in Taiwan during the late 1940s and early 1950s.[20] Rice could make up for caloric intake, but it was lacking in macro- and micro-nutrients needed for a healthy diet, including proteins and vitamins.

In 1948, the FAO Nutrition Committee met in the Philippines to discuss how to supplement the nutritional intake of rice-consuming societies like Taiwan.[21] Their suggestion was to consider yeast, which provided vitamin B and protein that were usually deficient in rice-consuming societies.[22] Food yeast had been utilized for several decades around the world. In the 1940s, the British colonial government in Jamaica grew Torula yeast (*Torulopsis utilis*) on molasses, plentiful in Jamaica's sugar cane agriculture.[23] Germany also produced Torula yeast in response to food shortages during World War II. In Germany, Torula yeast was predominantly grown on sulfite liquor, a liquid byproduct of wood pulp production that contained 3–4 percent sugar, of which the majority were five-carbon sugars that were not capable of being utilized by baker's or brewer's yeasts (*Saccharomyces cerevisiae*) but could be utilized by Torula. German usage was documented by American observers at the end of the war and disseminated in the US scientific literature, and in the late 1940s, several American plants also adopted the German method of producing Torula using sulfite liquor and sold Torula as an additive to other processed foods like soup and sausage mixes.[24]

Taiwanese authorities sought to follow the same idea and produce Torula yeast using a byproduct of sugar production, as was done in Jamaica. Sugar was a major agricultural commodity of Taiwan dating back to the Qing dynasty, with Taiwan at one point in 1934 being the world's third largest producer of sugar behind India and Cuba.[25] Its production under the ROC was organized under a state-owned enterprise that operated a monopoly on sugar-cane growing and sugar refinement, the Taiwan Sugar Corporation (台灣糖業公司, Taiwan Tangye Gongsi, or 台糖 Taitang for short). In 1954, with funding from a US International Cooperation Administration loan, Taiwan Sugar was contracted to convert an alcohol production plant in Xinying (新營), near the southern port city of Kaohsiung, into a yeast-processing plant.[26] The process grew Torula yeast using blackstrap molasses (糖蜜, *tangmi*), which was a byproduct of the final stage of sugar refinement. Blackstrap molasses was the leftover material that could not be refined any further using economical methods, and it had a high sugar content ranging from 50 to 55 percent, so it could be readily utilized as a cheap source for yeast production.[27]

In 1959, Taiwanese and American experts working on the Xinying yeast plant (officially the Xinying Byproduct Processing Plant, 新營副產加工廠, Xinying Fuchan Jiagongchang) discussed ways to turn Torula yeast into marketable food products. Yeast food products consumed in Western markets became a point of discussion. Xinying Plant Manager Qian Huining (錢輝宁, H. C. Chien) had left a two-ounce jar of Marmite, a British food product created through yeast autolysis (the breakdown of yeast cells) and flavored with salt and other additives, with a food-processing consultant from J. G. White Engineering, John Godston. J. G. White, an American consultancy that specialized in large scale industrial projects, had been advising the Nationalist regime in its industrial economic policy since 1948 when it was still on the mainland, in Shanghai, and moved with the GMD to Taiwan.[28] Godston wrote in reply that Marmite was not the only such product available in Western markets, citing Bovril's competition as a yeast product in the United Kingdom. Godston also raised the potential for yeast in military contexts, especially the need to provide flavor and nutrition in army rations. He suggested that a Marmite-like product could be used to flavor canned beef, pork, and fish, given the "excellent meat-like flavor" of Torula yeast. Godston asked Qian to produce a sample of yeast-flavored army rations for the military from the Taiwan Sugar Corporation laboratory.[29]

And Torula yeast was not limited to consumption by humans. One of the targets for Torula yeast was for hog feed. In the 1950s, hog feed consisted primarily of soy beans, which were predominantly imported at high cost, and sweet potatoes, which was also a human-consumed staple crop and a low-cost substitute for rice.[30] As sociologist Liu Chi-wei has argued, hog production and consumption of pork was vital to the commercialized, industrial food production in Taiwan emerging in the postwar era that created a dependency on foreign and US grain imports.[31] In a report from Taiwan Sugar Corporation president Yang Jizeng (楊繼曾, C. T. Yang) to J. G. White adviser Valerie de Beausset, Yang explained that one ton of dry yeast could provide the nutritional equivalent of three tons of soybeans, thus allowing a significant reduction in soy imports, which amounted to around a hundred thousand tons per year in 1956.[32] For the 2.8 million estimated hogs in 1956, this amounted to a significant potential market for Torula yeast. Yang argued that yeast was also a superior feed ingredient as well, producing less indigestion and diarrhea among pigs compared to the prior feed cakes that contained soybean oil as a significant source of nutrition.[33]

The largest issue faced by Taiwan planners, however, was that of cultural adaptation. As scholars such as Seung-joon Lee have shown, cultural preferences for foods hold significant sway over how humans consume their diets, even to the point of demonstrating pickiness during times of famine.[34] Unlike in Great Britain or the United States, in Taiwan, yeast was not usually consumed as a food but rather as a medicine for indigestion in the form of the imported Japanese drug Wakamoto (若元錠, Ruoyuanding). In its industrial production, Taiwan Sugar "had difficulty disposing" of yeast, despite it having value "from a nutritional point of view," implying the lack of demand stemmed from taste preferences.[35] In 1953, the Taiwan Sugar Corporation, in cooperation with the JCRR, the Taiwan Provincial Department of Education, and the Education Bureau of the Taipei Prefecture Government, conducted a food study of new yeast foods in primary school children. Dry yeast was distributed to every student across several schools in the Taipei vicinity, first in five-gallon tins, then redistributed to empty reused milk-powder cans, then provided to individual children in paper cones and supplemented with boiling water. Children were advised not to chew the yeast, "in order to avoid its sticking to gums and teeth," which many did not heed and that led to some minor gum irritation in some cases.[36] Overall, however, the report was upbeat and optimistic.

The study, prepared by nutrition specialist Yang Yueheng (楊月恆, Yang Yueh-heng) and Ralph N. Gleason, the American head of the Food and Fertilizer division of JCRR, and published in 1955 by the JCRR, suggested yeast supplements would be an important part of Taiwanese diets going forward.[37] In the tracked students, a 15 mg daily supplement of dry yeast to the average daily diet of 300 g of polished white rice provided increases to key vitamins as a percentage of daily recommended nutritional intake, from 30 percent to 40.83 percent of thiacin, 10 percent to 49.44 percent of riboflavin, and 37.5 percent to 90.25 percent of niacin.[38] The concluding recommendations called for creative combinations of yeast with other food pathways, such as enriching commonly used sweet potato and wheat flours with yeast to supplement vitamins, combining yeast with bone meal powder to also combat calcium deficiency in children, and introducing yeast into more food products instead of providing it merely as a nutritional supplement. Indeed, Yang and Gleason also understood that cultural affinities mattered—they recommended more attractive packaging than the plain tin containers and enhancing it with flavor additives so yeast could be added to soup, as was done with Torula in the United States at the time.[39]

Taiwan was keen to promote its yeast production activities as a sign of its progressive science-based food regime internationally. In the February 1960 issue of the US-based journal *Food Engineering*, Qian published a four-page article outlining the yeast production process at Xinying and its contribution to Taiwan's nutritional and economic needs. Qian began by contextualizing the problem in Taiwan, with a prolific agricultural economy centered on rice and sugar cane (representing 90 percent of its production) yet with poor nutritional sources of protein. As a result, Qian argued that "many people and their livestock will suffer severely from malnutrition. They will be starved for protein." Enter yeast. Qian argued that yeast was comparable in its amino acid content to milk casein and in its vitamin B content to liver. Most attractive about yeast aside from its nutritional content was its economy—fast and easy to grow, and efficient in terms of its land usage and input requirements.

Qian's article emphasized the technical aspects of yeast production in the Xinying plant, showcasing modern equipment, precision measurement, and factory-like efficiency. Qian pointed out the "rigid laboratory control in every stage," such as stainless steel equipment that allowed for careful control of pH levels and preventing the introduction of unwanted organisms and contaminants. There were "super-speed spray dryers" that allowed for "ultra-fine powders that directly form colloidal suspensions when stirred into water," in other words that rendered the yeast more dissolvable in water (and thereby preventing the sticking to the gums that plagued the Taiwanese schoolchildren in the JCRR study). Tests were implemented throughout the production process, including spectrophotometers to ensure vitamin content in the yeast product.[40]

Qian furthermore raised the possible applied food uses of Torula yeast. One was the aforementioned yeast autolysates, such as Marmite, that could be used to provide both the nutritional advantages of yeast and the glutamic acid that added an umami flavor. Other possibilities included adding a 2-percent yeast supplement to ground flour or including it in soy sauce fermentation, which would raise protein and vitamin B content.

In the end, however, Torula yeast did not become a mainstream food product, much for the same reasons it did not take off elsewhere: taste. As a direct supplement, the stickiness to gums and the unusual texture likely found few lovers among Taiwanese schoolchildren (see figure 36). Unsurprisingly, when food yeast did take root in Taiwan, it was not a yeast autolysate like Marmite or additives to canned meats or basic food commodities but something where the taste of food yeast was fundamentally altered—literally, sugarcoated. It was a yeast candy, *jiansutang* (健素糖, also known as *xiaosutang* 酵素糖).

Jiansutang stemmed in part from the conclusions of the 1955 JCRR report from Yang and Gleason that nutritional supplements were especially important for youth development. Whereas protein and vitamin B supplements could be added in other ways, candies appealed to children in a way that yeast autolysates like

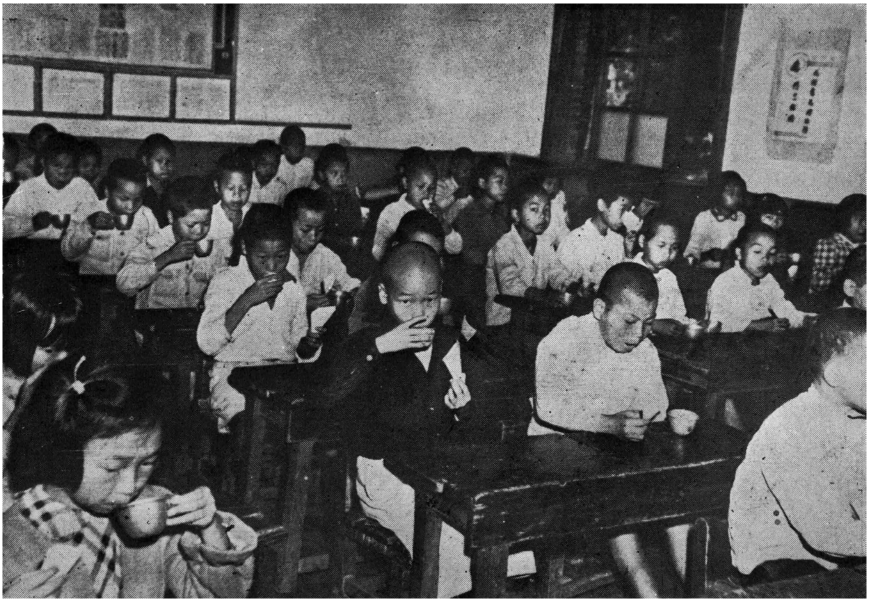

FIGURE 36. Elementary school children in Taiwan consuming the Torula yeast provided by the JCRR. Yang and Gleason, *Yeast-Feeding Demonstration*, 5.

Marmite did not. Shaped like colorful flattened spheres that resembled Skittles candies sold today, *jiansutang* became a hit in Taiwan. Taiwan Sugar advertised *jiansutang* as a healthy food for adults and a tasty nutritional supplement for children, with fruit and cocoa flavors (see figure 37). In the decades since the creation and marketing of yeast candy in Taiwan in the late 1950s, *jiansutang* has become a standard fixture in Taiwanese youth consumption. One popular television report from major Taiwanese news channel TVBS in 2006 described it further: "Because of its colorful exterior and its slight sweetness, parents often purchased it for their children to supplement their nutrition. From the early resourceful packaging in a plastic bag, to the current sealed aluminum containers, *jiansutang* has never utilized advertising, but still has existed for 50 years" (though it seems that *jiansutang* was indeed advertised in the 1960s at least).[41]

For the Taiwanese planners behind Torula yeast, though nutrition was an important objective, the developmental needs of Taiwan were nonetheless the most important. Behind discussions of daily protein requirements was the idea that yeast was cost efficient and could yield industrial levels of production in the food realm. Indeed, nutrition was not seen in this context as an end in and of itself but rather as the means to a different end: a modern, capitalist, and industrial economy that applied the latest in food science and production technologies. By the late 1960s, when Taiwan had already achieved significant levels of improvement in nutrition from the 1950s, the instrumentalist and social nature

FIGURE 37. *Jiansutang*, yeast candy manufactured by Taiwan Sugar Corporation with Torula yeast, advertised as a nutritional supplement for children and adults in *United Daily News*. Taiwan Sugar Corporation, *United Daily News* (聯合報 , Lianhe bao), January 1, 1965.

of nutrition persisted. Then, in the 1970s, nutrition arose again in a scientific discourse on vegetables.

VEGETABLES

Although yeast did not become a widespread staple or supplementary food as some nutritional experts in the JCRR might have hoped, Taiwanese diets did shift from the "public diets" controlled by the GMD in the 1950s to increasingly diversified food sources over the decades that followed. This entailed decreased consumption of the primary cereals—rice and sweet potato—and an increase in consumption of pork, chicken, eggs, vegetables, and fruits (see table 1). For example, from 1960 to 1964, rice and sweet potatoes accounted for a total consumption of 188 kg per capita. By 1985–89, this had dropped to 77 kg per capita, approximately 41 percent of the 1960–64 amounts. Much of this was made up for with eggs, milk, vegetables, fruits, fish, and meat, which doubled, tripled, or even quadrupled in per capita consumption.[42]

TABLE 1 Taiwan's Agricultural Production, Consumption, And Trade

	1960–64	1965–69	1970–74	1975–79	1980–84	1985–89
Agricultural production as % of GDP	29.7	23.6	15.1	12.5	8.7	6.3
Production index (1986 = 100)	41.1	53.8	66.4	80.6	92.4	105.5
Production growth rate	4.5	4.8	4.2	5	1.7	2.4
Percentage of crop-livestock value:						
Crops	74.5	73.6	67.5	64.1	62.6	59.7
Rice	40.2	35.2	30.7	29.1	24.4	17.3
Sugar	6.6	4.8	4.5	5.7	4	3.9
Sweet potatoes	7.7	7.7	5.7	2.9	1.6	0.6
Fruits and vegetables	8.2	14.7	17	18	24.4	28
Others	11.8	11.2	9.6	8.4	8.2	9.9
Livestock and products	25.5	26.4	32.5	35.9	37.4	0.3
Hogs	17.7	17.2	20.7	20.5	20.3	24.9
Chickens and eggs	3.2	4.7	5.9	9.6	11.4	11.1
Others	4.6	4.5	5.9	5.8	5.7	4.3
Per capita consumption (kg)						
Rice	134.2	138.1	133.3	120.6	92.8	75.9
Sweet potatoes	53.8	38.9	15.5	7.1	2.7	1.1
Meats	16.8	23.8	27	34.1	46	57.4
Eggs	1.8	3	4.4	6.6	9.3	11.3
Fish	25.7	29	35	36.1	35.6	43
Milk	6.3	6	12.4	20.2	27.1	34.8
Vegetables	58.3	60.9	91.8	118.6	121.3	123.1
Fruits	20.4	34.5	49.1	59.1	73.1	94.7
Agricultural exports (per 1,000 tons)						
Rice	88.5	110.6	21.8	159.4	280.4	125.1
Sugar and products	712.9	758.6	509.1	455.1	275.2	85.6
Hogs and pork	3.1	2.3	16.3	18.4	30.2	102.9
Processed fruits and vegetables	95.8	211.6	363.5	505.8	517.4	391

Huang, "Structural Change in Taiwan's Agricultural Economy," 43.

The diversification of diets is unsurprising. As wages and economic conditions improved in Taiwan, so too did purchasing power, which led to the demand for more expensive and varied foods. Taiwanese farmers also increased production in non-cereal foods, which fetched higher prices and potentially higher profits. These also aligned with nutritional goals from government experts like Yang Yueheng, who recognized the importance of proteins, vitamins, and minerals for public health. But it also demonstrates that nutrition and public health are inseparable from political economy. Though the ROC state made efforts to increase nutritional uptake, such as introducing yeast into primary schools, ultimately it was rising incomes and decreased food costs that diversified the average diet among the Taiwanese.[43]

Further demonstrating the integrated nature of food and capitalism, Taiwan also focused on higher-margin foods that could be exported, especially vegetables, fruits, and processed foods. By 1963, Taiwan had become the world's leading exporter of pineapples.[44] During the 1970s, this grew to include canned pineapples, asparagus, and mushrooms.[45] During the 1975–79 period, processed fruits and vegetables overtook sugar and sugar products as the largest agricultural exports of Taiwan by volume, marking a shift from an agricultural commodity to higher-profit-margin and higher-value-added products (see table 1). In reaching this position, Taiwan developed special expertise in locating higher-margin products and markets. Sophia Wu Huang, an economist with the US Department of Agriculture's Economic Research Service, has argued that the shift in focus to processed foods stemmed from a need to earn foreign exchange, while taking advantage of Taiwan's ample labor supply in producing the labor-intensive canned products.[46] After the cessation of US development aid in 1965, Taiwan particularly focused on improving the marketing of Taiwanese processed foods abroad, which helped it secure its global market position.

These nutritional and profit-oriented changes played out as well in international development. In 1971, Taiwan founded its answer to IRRI that it hoped would put Taiwan in the global food map the way IR-8 did for the Philippines and CIMMYT did for Mexico: the Asian Vegetable Research and Development Center (AVRDC) (亞洲蔬菜研究發展中心, Yazhou Shucai Yanjiu Fazhan Zhongxin). An official history published by the AVRDC credited the initial idea to Frank Parker, an assistant director for research and technology at USAID. According to that history, the idea for a center specializing in vegetables emerged just soon after the founding of IRRI, in 1962.[47] Parker was an agronomist trained at the University of Wisconsin with significant international experience in India and with the UN Food and Agriculture Organization. He and others within USAID identified vegetables as the next frontier in agricultural science after cereal grains. In 1967, Eugene Black, former president of the World Bank and at the time special adviser to President Johnson, wrote to David Bell at the Ford Foundation describing the need for a vegetable research institute. With the cereal grains of the CIMMYT and the IRRI, wheat and rice, providing a raw caloric boost to the underdeveloped areas of the world, USAID saw "the need to augment and improve the high starch diet of the people in East Asia, and to increase rural income by upgrading the production, processing and marketing of vegetables."[48] Another document from the State

Department that chronicled the founding of the AVRDC reinforced this, framing the "research center" as one "to improve the diets of the Asian people by increasing the production of protein and protective vegetable foods."[49] This signaled a move beyond hunger and instead to a more holistic understanding of human livelihood and health based on nutrition, and especially household income as a means to germinate a household capital-led national growth.

Initial conversations among USAID and its development recipient nations identified three possible hosts in the Philippines, Thailand, and Taiwan.[50] Taiwan was particularly keen to see that the center be established in Taiwan.[51] Jiang Yanshi (蔣彥士, Y. S. Tsiang), a former commissioner of the JCRR who was Frank Parker's roommate while visiting a conference at MIT in 1964, introduced Parker to Taiwanese horticulturalist, Lu Zhilin (陸之琳, C. L. Luh). Lu was a graduate of Nanking University and then was the head of the Plant Industry Division of the JCRR, thus overseeing projects for improved varieties of fruits and vegetables in Taiwan. Lu would eventually serve as the associate director of the AVRDC. While in the JCRR, Lu pointed to the shift in Taiwan's development strategy after 1965 in a paper presented at a workshop on "Accelerating Agricultural Development" in Los Baños in 1976 that included "production of more nutritious food crops . . . containing more protein and vitamins and to the development of food processing industries."[52] This also complemented an increased focus on fisheries and animal husbandry in order to produce animal protein. Taiwanese bureaucrats and scientists thus also perceived the need to focus on nutrition instead of just calories.

The proposal eventually reached the desk of ROC minister of economic affairs Li Guoding and ROC premier Yan Jiagan (嚴家淦, C. K. Yen), who made the center a priority in discussions with USAID director David Bell. Though a formal proposal was drafted by Lu and submitted to the USAID by 1965, the center would not come to fruition until 1971 because USAID (in part driven by a desire within Congress for cost sharing from America's Asian allies) was unwilling to bear the full costs of the project alone. JCRR chairman at the time, Shen Zonghan, spent over half a decade pursuing funding from the Rockefeller Foundation, Ford Foundation, and Cornell University before finally securing the funding he needed. In 1972, the AVRDC finally opened its doors in Shanhua, located in southern Taiwan.

The ROC government granted 116 hectares of land to the AVRDC that was formerly a sugar cane plantation for the Taiwan Sugar Corporation.[53] The AVRDC hosted a research staff from a half dozen Asian nations—Taiwan, Vietnam, the Philippines, Japan, Korea, and Thailand.[54] It operated with a $1.5 million per annum budget in its first five years, 5 to 10 percent of which was contributed by most AVRDC member countries with the rest being covered by Taiwan, the United States, the Asian Development Bank, and the Ford and Rockefeller Foundations. Shen Zonghan, who at the time served as the chairman of the AVRDC Board of Supervisors, already had in mind Robert F. Chandler, who was due to

FIGURE 38. The Asian Vegetable Research and Development Center (now the World Vegetable Center) in Shanhua, Taiwan. Photo taken by author in 2013.

retire at the end of his term as director of IRRI. Chandler had been instrumental in establishing IRRI as its first director, and according to the official narrative, the board members who came from the Asian nations preferred an American as a director.[55] Chandler's background, having established and led the successful IRRI during its first decade, most probably appealed to Shen, who wanted the AVRDC to be Taiwan's IRRI.

The objective for the center was to serve the people of tropical and subtropical climates of East and Southeast Asia. The large variety of vegetables in Asia was daunting, so an initial focus was placed on six fruits and vegetables: tomato, soybean, mung bean, sweet potato, white potato, and Chinese cabbage. These vegetables were chosen based on their wide cultivation across multiple societies and climates. In the cases of the legumes and potatoes, they were also chosen because they provided a relatively large amount of calories. The AVRDC's mission of vegetable improvement included locating and storing different varieties from throughout the world, thus functioning as a seed bank, then selecting varieties that produced higher yields and higher-quality crops, as defined by resistance to disease, pests, and adverse climates.[56] Like TARI and other Taiwanese research and experiment institutions, the AVRDC collected cultivar samples, planted them comparatively in different experiment plots, and recorded results for analysis of factors such as response to fertilizer, resistance to disease, crop yield, and so forth. The difference was that the AVRDC's scope was far larger; in addition to collecting seeds globally, it sought to test its seeds for climates that would be applicable across Southeast and East Asia.

The AVRDC staffed and trained scientists in plant breeding, plant pathology, plant physiology, soil science, and chemistry, the typical sciences that constituted Green Revolution technologies of seeds, fertilizers, and pesticides.[57] As explained to Ford Foundation president David A. Bell by the AVRDC's training director, AVRDC training aimed to allow trained scientists, technicians, and extension agents to return to their home countries and "have the opportunity to make their own selections from the crosses they made while studying at AVRDC and to develop the production technology appropriate for their own local conditions [*sic*]."[58] This type of localization where trainees were given the expertise to make their own decisions based on their knowledge of local conditions showed the deference to local knowledge and a desire to make AVRDC seeds globally applicable.

Shen Zonghan, on the opening ceremony day, attributed the basic mission of the AVRDC to improving the "normal diet" of the average Asian citizen.[59] Shen proclaimed that vegetables weren't an "exotic crop" and would certainly be consumed widely in Asian society. Economic factors played a major role as well. Shen emphasized the greater profit potential from vegetables compared to cereal grains and their versatility for being grown in either home gardens or commercially for export.[60] These objectives underscored improving agricultural industries, agricultural productivity, and rural livelihood. Shen recognized that the introduction of foreign cultivars, typical of Green Revolution methods, was not a simple matter; local cultures were not always open to the taste of new foods. The improvement of local vegetables thus became a major objective of the AVRDC. Simultaneously, vegetables provided broader economic benefits, due to its higher profit margins and ability to be grown at both small and large scales, which had the benefit of improving mass agricultural industries as well as employment and revenues for individual farmers at rural and village levels. Finally, Shen indicated that vegetables could spawn dependent industries through postprocessing, such as canning for export.

Reflecting changes within international development, the AVRDC's focus on vegetables took aim at a rising concern: nutrition. With the increase in chemical inputs and the usage of high-yield varieties that responded well to fertilizers, many former Global South nations had fulfilled the basic caloric needs of their citizens. The development field turned its attention to making sure that diets provided healthy levels of minerals, vitamins, and other aspects of nutritional sufficiency. In making a case for why vegetables to the Technical Advisory Committee of the Consultative Group of International Agricultural Research (CGIAR), the AVRDC's first director, Robert F. Chandler, argued in 1972 that "looking at human nutrition alone, we should not forget that polished rice contains no vitamin C and no vitamin A, while many vegetable crops produce abundant amounts of these essential constituents for human nutrition."[61] Vegetables played well into this evolution past staple crops, and the addition of mustard green, cauliflower, snap pea, radish, and pepper in 1981 demonstrated that there was demand for vegetables beyond the staple crops such as legumes and potatoes that were the core of the AVRDC's efforts in the 1970s.[62]

As mentioned in Shen's opening-day speech, home gardens became an important avenue identified by AVRDC officials where vegetables could make a difference in both nutrition and economic livelihood. In explaining the rise of home garden research, the AVRDC explained that a small, four-by-four-meter garden could provide "enough vegetables to provide a family of five with a significant percentage of their recommended dietary allowance of protein, calcium, and iron, and complete requirements for vitamins A and C."[63] Yet the AVRDC's home garden project also identified economic uplift as an important goal alongside nutrition. Part of this is attributable to the integration of anthropologists into the AVRDC home garden program. Historian Leo Chu in particular identifies Berkeley-trained anthropologist Jack Gershon, who came to the AVRDC in 1980, as envisioning the AVRDC's home garden program, called "nutrition gardens," as filling in a void left by capitalist agriculture. Specifically, home gardens would target the small farmers who had "neither the large field for, nor the capital to invest in, fertilizers and pesticides."[64] The result was a training regimen focused on manual weeding and insect control, compost, and mulching.

Despite its idealistic outlook in an era where capitalist, industrial agriculture was still the norm, the home garden program encountered substantial issues. The AVRDC had integrated home gardening as part of its Thailand Outreach program. Yet the AVRDC's Thailand home garden program reflected a gender bias not uncommon in the development field during the 1980s. Home gardens were generally tended to by women, since women were "generally responsible for the family's food." Eighty percent of those involved in the AVRDC's home garden programs in the Philippines, Indonesia, and Thailand were female.[65] This gender disparity demonstrated how ideas influential in agricultural economics continued to allocate resources toward gendered divisions of household labor.[66] The designation of "family food" as a woman's responsibility indicated that women were still primarily seen as responsible for the health of the household, including the young and elderly. A later 1992 report evaluating the home garden program criticized how the home garden program disregarded gendered dynamics. Specifically, the AVRDC ignored that women were asked to take on large parts of household management, not just in terms of care but also managing the household as men in Thailand increasingly worked as migrant laborers in urban areas. The result was that few women had the resources or time to take on home gardening, and furthermore, decisions on home gardening, such as purchase of seeds and tools, still required the approval of men in the household.[67] In turn, this affected the AVRDC's mission focused on nutrition.

Home gardens and vegetables offered a promising venue for the AVRDC to pursue a goal of future relevance for itself and for Taiwan. Leveraging increased attention to nutrition and economic livelihood, the AVRDC pursued a path of scientific research and dissemination that it believed was missing in the larger field of international development.

FERTILIZER

Chemical fertilizers anchored industrialized agriculture in Taiwan. As chapter 3 explored, chemical fertilizers not only provided the necessary catalyst for Green Revolution agricultural productivity but in Taiwan also went hand in hand with authoritarian state power and top-down processes of rural control. The Food and Fertilizer Technology Center (FFTC) (糧食肥料技術中心, Liangshi Feiliao Jishu Zhongxin), established in 1970, directly drew on the importance of fertilizer for its mission. The FFTC was an idea first proposed as a "food and fertilizer bank" by the Taiwan government to the Asia-Pacific Council (ASPAC) (亞洲太平洋理事會, Yazhou Taipingyang Lishihui) in 1966.[68] Founded in 1965 and organized initially by South Korea (the Republic of Korea), the ASPAC was a short-lived organization of Asian states: Australia, the ROC, Japan, South Korea, Malaysia, New Zealand, the Philippines, the Republic of Vietnam, and Thailand, with Laos as an observer. At times called an "anti-Communist" and an "anti-Chinese" (PRC) league, and even suggested as the Northeast Asian equivalent of the Southeast Asia Treaty Organization (SEATO), the ASPAC consisted of non-Communist Asian states in a Cold War context. The function of the ASPAC was ambiguous and contested through its history, which in part contributed to its eventual dissolution in 1975. Members agreed to convene an annual forum of foreign ministers from member nations and to form multilateral institutions to serve member nations, such as the Registry of Scientific and Technical Services (based in Australia), a Social and Cultural Center (based in South Korea), an Economic Cooperation Center (in Thailand), and then the FFTC. The notable exclusion of the United States in the ASPAC proved to be a selling point for the organization, as several member nations wanted to maintain distance from Washington, but other members, including Taiwan, sought to militarize the ASPAC, which would effectively form an anti-Communist security organization. In this fashion, the ASPAC can be understood as a Cold War parallel to the US-centric network from which the AVRDC was born.[69] This latent anti-Communist orientation shaped its economic and scientific endeavors.

The FFTC was originally conceived of as a bank serving ASPAC members, not a research institution. The memorandum drafted in 1966 envisioned "an economic agency . . . to carry out mainly the activities concerning the operation of food and fertilizer warehouses and related financing work."[70] In furthering Green Revolution goals of industrialized agriculture, the focus on warehouses was meant to ensure that fertilizers would be able to reach rural villages as efficiently as possible. Much as the Industrial Revolution did not just entail changes within the factory floor but also through the vast armadas of ships, railroads, ferries, trucks, shipping boxes, and other vehicles and machines that crossed the globe, so too did the question of getting fertilizer from point A to point B become a key concern. As the memo further detailed, "Preferably the existing warehouses of the participating countries shall be utilized to store the food and fertilizer contributed by participating countries and to distribute them to other participating countries in need of these commodities."[71] The logistics of fertilizer supply, storage, and distribution, the physical infrastructure supporting those logistics, and the market mechanisms of supply and demand between centralized production areas and areas of consumption—that is, between rural and urban—remained salient issues for decades in Taiwan.

The goal of the Food and Fertilizer Bank was also framed in terms of multinational cooperation and the mutually beneficial goals of cooperative research. It aimed to "promote and increase the production and supply of food in the region through the interflow of food and fertilizer among the participating countries as well as the interchange of production technique and the stabilization of market supplies and prices with a view to solving the food problems now confronting most countries within the region."[72] It was believed that regional cooperation would be mutually beneficial and produce a greater overall good. The anti-Communist leanings of ASPAC members meant that these food problems were also linked to concerns over Communist spread.

Inherent in this regionalism was the assumption that the prime way to resolve food shortage was through market mechanisms, namely supply and production. Regional integration meant that the fickleness of the market could be overcome by linking supply markets, thus overcoming potential pains due to cycles of increased demand or decreased production. Shen Zonghan in 1967 wrote Xie Senzhong, his friend at the Asian Development Bank and former colleague at the JCRR, that "fertilizer is the most important" of production requisites and that the proposal for the bank would "promote the interflow of fertilizers among the countries through market development, exchange of technical information, credit arrangement and adjustment of demand and supply."[73] In other words, there was a faith in and a desire to expand upon a capitalist Green Revolution.

However, by 1968, the institution became reconceived as a "center" instead of a "bank," but the FFTC nonetheless retained its emphasis on the technical aspects of getting fertilizer to where it was needed. A JCRR document from that year emphasized "the increase of food production through increased application of chemical fertilizers" and "the need for increased use of fertilizers as a direct and speedy way of uplifting food production in the Asian-Pacific region," demonstrating once again the importance of chemical inputs for agricultural development.[74] What changed more was an emphasis on technology specifically, "an exchange of technical information and experiences" instead of a focus on infrastructure and regionalizing supply markets. Thus, like the AVRDC, an emphasis was placed on techniques, technologies, and knowledge in general. This shift in focus to technology also trimmed the FFTC's projected budgets, which was a concern to ASPAC members who were expected to contribute to FFTC operations. In the end, the idea of a center received a warm, but not ecstatic, reception in the ASPAC. It was referred to a subcommittee, and after 5 years it finally was completed in 1971 in Taipei with representation from Australia, the ROC, Japan, South Korea, Malaysia, New Zealand, the Philippines, the Republic of Vietnam, and Thailand.[75]

The 1970 annual report presented to the sixth meeting of the ASPAC showed results from its first year of operation. The results demonstrated a far more modest scope of activities than the initial discussions in the ASPAC might have implied. They included the following: (1) short-term training courses for extension workers from Thailand, Vietnam, and Malaysia; (2) seminars on "Crop Physiology and Fertilizer Application" bringing together experts from all the FFTC founding member nations except Australia; (3) writing and disseminating information bulletins, both of more technical nature for a scientific audience and of a general nature for extension workers; (4) a demonstration project (planned for the following year); and (5) feasibility and consultative trips.[76.] The final aspect, feasibility trips, allowed the ASPAC to determine in its early years how best to aid the needs of its members.

The first year consisted of two feasibility trips, surveying Malaysia, Vietnam, the Philippines, Thailand, and Japan. The report of the feasibility trips remarked on a number of aspects. There were concerns over exchange rates in the Philippines making the purchase of fertilizer more expensive for farmers, which created concerns among Filipino policymakers that farmers would as a result use less fertilizers and drive down production. Observations included how credit for fertilizers was extended in Vietnam, as well as plans for the construction of a domestic fertilizer production plant, albeit with concerns about whether domestically produced fertilizer would in fact be cheaper than imported fertilizer. In Japan and Thailand, which both produced surpluses of rice and thus were net exporting countries, different problems were recorded. Thailand faced global decreases of rice prices, thus making exports less profitable. Japan, on the other hand, faced a shrinking agricultural labor market due to its rising industrial sector (a problem Taiwan would soon face).[77]

In synthesizing the findings of these feasibility surveys, FFTC staff wrote that there were common areas of interest for further research and demonstration: irrigation, fertilizer production and trade, fertilizer regulations and marketing, short-term consultants, and training courses.[78] These aspects once again reflected the ongoing changes in Taiwanese agricultural development and the growing hegemony of the Green Revolution. This was true in fertilizer especially, which combined the high modernism of Green Revolution soil science, plant breeding, and chemistry, as well as agricultural economics, development economics, and international trade. Though extension and farmers' associations were seen as crucial, they became more a means to an end than the end itself.

Over the years, the FFTC remained an organization limited in both scope and size. Its initial year of operation planned for only thirteen employees, two of whom were drivers.[79] Over time, its mission shrunk even further. On the back cover of a conference paper published by the FFTC from one of its sponsored 1981 conferences, the organization described its own mission as "to collect and disseminate agricultural information throughout the Asian Pacific region," which differed greatly from the mid-1960s conception of an economic agency designed to build and foster a logistical network to facilitate the shipment and usage of chemical fertilizers.[80] The FFTC's limitations were in part financial, as its initial nine founding member countries dwindled to six. When I visited the center in 2013, the office space and staff were both relatively small. Despite Taiwanese government efforts to co-opt fertilizers from the Green Revolution, the FFTC never reached the heights of more well-known research institutions like the IRRI or even the AVRDC.

GEOPOLITICS

As historians John Perkins and Nick Cullather have argued, the Green Revolution was inextricable from the global Cold War.[81] Green Revolution science was co-opted explicitly as a form of anti-Communism—replacing "red" revolutions with a "green" one. Taiwan's co-opting of its agricultural science was similarly done for political purposes. In 1971, the Republic of China had lost its seat in the UN to the PRC. This led to the paring back of Vanguard missions and reduction of efforts by the Ministry of Foreign Affairs to trade development diplomacy for UN votes (see chapter 5). Country-to-country development missions continued to the dwindling number of ROC allies that continued to maintain diplomatic relations after the ROC's departure from the United Nations.[82] Institutions like the AVRDC and the FFTC, however, attempted to counter those geopolitical currents through agricultural science.

Taiwanese state planners viewed the AVRDC and the FFTC as vehicles for building closer international relationships through global agricultural science. The USAID initially envisioned the AVRDC as becoming an internationally oriented research center like the IRRI that serviced Asia and the rest of the world, with US East and Southeast Asian allies both contributing funding and benefitting from the research. Both institutions enmeshed Taiwan within the American Cold War network. This was a natural extension of United States hegemony in the Pacific following the Korean War, when fears of a Communist domino effect gave rise to US intervention and support of authoritarian, anti-Communist regimes in East and Southeast Asia.[83] Establishing the AVRDC with the financial and political support of the United States allowed the Guomindang regime to forge closer international ties with other US allies after the loss of the ROC's seat in the United Nations to the PRC in 1971.

One of these allies, South Korea, expressed concerns over its financial contributions to a center specializing in subtropical vegetables. To address those concerns, the AVRDC early in its history established a "sub-center" in Suwon, South Korea, to provide vegetable experimentation in the more temperate Korean climate.[84] Founded in 1974, the Suwon sub-center was led by horticulturalist Chung-il Choi (최정일), an AVRDC board member and head of the Horticultural Experiment Station operated by the South Korean Office of Rural Development.[85] The first Suwon sub-center reflected both scientific (climate) and political (influence) concerns, but the latter would prove to be more problematic in years to come.

The AVRDC's first director, Robert F. Chandler, indeed fielded concerns in the opposite end, too, that Taiwan's relatively northern latitude in a subtropical zone would not produce vegetables well suited for more tropical climates.[86] A more southernly regional center was thus a major goal of the AVRDC. In 1981, the AVRDC established its first outreach program in the tropics (most of Taiwan is subtropical). The AVRDC Thailand Outreach program was sponsored by the Thai government and the Asian Development Bank.[87] It eventually grew to become one of three AVRDC regional centers focused on different areas of the world. The other two, in Tanzania and Costa Rica, covered Southern Africa and Latin American and the Caribbean, respectively.

As the AVRDC expanded, its regional centers focused more on cooperating with specific nations to localize seeds developed from Taiwan for local climates and soils. Regional centers were envisioned as operating hand in hand with national agricultural research systems, referring to the agricultural research and experiment stations of individual nation-states. The AVRDC was thus working with state partners, as opposed to directly to communities. This benefitted Taiwanese state objectives, too. Seeds developed from the AVRDC inevitably showcased Taiwan's central role in funding improved varieties for the purpose of increasing food production. Simultaneously, these seeds also offered a more visible platform for Taiwan's scientific capabilities, which in turn reinforced an image that the authoritarian Guomindang regime was eager to underscore abroad and at home.

The AVRDC was led by scientists such as Shen Zonghan and Ma Baozhi (who would later serve as the chairman of the board after Shen's retirement), who advocated for science leadership on a regional, and later, global, basis. As Yan Jiagan, premier of the ROC at the time, later becoming vice president and then president following Chiang Kai-shek's death, described in the tenth anniversary speech of the founding of AVRDC:

> I can say without reservation that the work of AVRDC has by association cast a most favorable reflection on the ROC. The Center in many ways serves as a window to the world, enabling those who might not otherwise see our island come and judge for themselves. And, by implication, AVRDC's successes are our successes: they are the successes of our people who work here, the success of the good neighbors who live in the vicinity of the Center, and they are the success of our national research programs that in many instances work side by side with AVRDC.[88]

Like the Vanguard missions, they also demonstrated Taiwanese expertise in modernist science to the rest of the world. These efforts continued along Cold War networks, relying on expertise and funding from US allies in Asia such as Japan, Korea, the Philippines, Thailand, and Indonesia. Yet whereas the Green Revolution might have found success in spreading a model of industrialized agriculture across the world, Taiwanese efforts to co-opt the Green Revolution met the headwinds of Taiwan's geopolitical pressures.

Specifically, efforts by the AVRDC to seek international integration met political obstacles in the wake of the ROC's ejection from the United Nations. This began almost immediately after founding. By the early 1970s, the success of the CIMMYT and the IRRI prompted international development organizations like the Rockefeller and Ford Foundations to band together and encourage the growth of other international agricultural science institutions to focus on what historian Tim Lorek has called "mega-environment" research.[89] This led to the Consultative Group of International Agricultural Research (CGIAR), which today counts among its members the premier international agricultural research institutes around the world.

The AVRDC was not a formal member of the CGIAR due to Taiwan's contested status as a nation, which made its funding a political liability. Initially, the USAID's investment in the AVRDC was meant to be a one-time expense, with continued annual support coming from its constituent member nation-states as well as international organizations like the CGIAR. However, a US report to Congress by the comptroller general revealed the unexpected geopolitical conditions that prevailed. It referenced a USAID memorandum stating "AVRDC is barred from inclusion in the CGIAR overall budget support program for political reasons. . . The most persistent problem which AVRDC will continue to face is caused by international political realities; diplomatic recognition of the People's Republic of China by an increasing number of countries and the related severing of formal diplomatic ties with the Republic of China." It ended with a blunt reality: "AID believed that a number of CGIAR donor members would be likely to support AVRDC if it were elsewhere than Taiwan."[90] The USAID's concerns reflected that Taiwan's international pariah status constituted an insurmountable barrier.

Moreover, CGIAR officials expressed concerns over the domestic political environment in Taiwan, an implicit reference to the authoritarian politics of the Guomindang state and its potential effects on the conduct of science. A 1972 correspondence between Robert Chandler and Lowell Hardin, an American agricultural economist and professor of agricultural economics at Purdue who was instrumental in the formation of the CGIAR, illustrated this clearly. In the letter, Hardin explains the position of John Crawford, an Australian agricultural economist and then chairman of the Technical Advisory Committee (TAC) of the CGIAR: "It may be necessary for the Center to change its charter in order to assure autonomy necessary for freedom of scientists to operate."[91] Chandler defended the work of the AVRDC, reiterating several years later in a 1974 letter directly to Crawford that "the government of the Republic of China, located on Taiwan, in no way enters into our financial and scientific affairs, other than to make financial contributions toward our efforts. All of our negotiations for support for both core budget and outreach programs are conducted directly with donor agencies, and the government here is not even consulted."[92] Yet these entreaties ultimately had no effect.

Compounding the issue of not having CGIAR funding, the AVRDC had difficulty independently seeking external funding from non-CGIAR affiliated donors without the CGIAR's blessing. As Chandler summarized for Crawford in 1974, "Our Center has never received the full endorsement of the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research." When the Japanese delegate to the CGIAR asked in September 1972 "why AVRDC was not a full member," CGIAR chairman Demuth "replied that because of the international political situation, the CG[IAR] was headed for internal disagreement if the discussion continued. . . . Therefore they decided to give AVRDC associate membership only. Then he added words to the effect that the TAC had not recommended that high priority be placed on support for AVRDC." The result was that the AVRDC encountered difficulty seeking grants directly from other nations. And this entailed an effective marginalization of the AVRDC. An initial hope among the AVRDC to focus on twelve vegetable crops was halved to six due to the budgetary constraints and lack of funding. Chandler continued to express his frustration, noting that TAC had since endorsed and funded proposals for studies of the same crops that the AVRDC proposed in 1971 with other CGIAR institutions such as the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria, and International Center for Tropical Agriculture (CIAT) in Palmira, Colombia.[93]

In the same letter, Chandler expressed hope that the "two-China problem" might "await further political moves before it can be settled." Unfortunately, the political situation never changed. In 1975, a CGIAR mission sent to Southeast Asia included in its purview assessing the viability of greater CGIAR support for vegetables. The mission, led by TAC member Peter A. Oram, concluded that vegetables were indeed of utmost importance "deserving of international or regional action . . . because vegetables are such an important constituent of the general diet in Asia" and argued for further attention be paid to vegetables. Yet in the same report, he conveys the hope that "a new, fully internationally acceptable" research center would be proposed to replace the AVRDC, which would then be "phas[ed] out to become a national institution."[94] The report laid clear that the AVRDC's future was seen as untenable, with the politics of its location on Taiwan being the only mentioned concern.

The AVRDC was only able to be an associate CGIAR member, never achieving the full recognition and the benefits of the CGIAR. In CGIAR Technical Advisory Committee meetings where the AVRDC was discussed, representatives from the United Nations Development Programme needed to formally request "to be recorded as not participating in the discussion of" of AVRDC-related agenda items, showing how sensitive Taiwan was for UNDP representatives.[95] Though it maintained a scientific agenda that was global, its exclusion from international networks of funding spelled out its marginalized future. From 1971 to the 1980s, numerous founding member nations of the AVRDC and the Asian Development Bank withdrew their support, and in 1974, the Rockefeller Foundation, one of the key institutions behind the founding of the AVRDC, likewise withdrew its funding.[96] Other CGIAR institutions took up core objectives that the AVRDC had set out to accomplish in 1971, for example the International Board for Plant Genetic Resources and the aforementioned International Institute of Tropical Agriculture and International Center for Tropical Agriculture. As Chandler expressed to his friend Lowell Hardin, "I get the feeling (as you do too) that if it were not for the Geo-political factors, the going would not be quite so rough."[97]

The resulting isolation of the AVRDC frustrated the goals of its planners, which was to seek regional leadership through science and expertise. Yan Jiagan praised the efforts of the AVRDC despite its operating with what he bemoaned as "the smallest staff and the smallest budget of any of the international food crop improvement center."[98] Though its initial attempts were limited to East and Southeast Asian networks, it was in fact the lack of inclusion in the CGIAR, the withdrawal of its international networks, and the resulting limits on its budget that ultimately forced the AVRDC to the sidelines as the Green Revolution continued without it. The AVRDC continues today as the World Vegetable Center, but it never quite became the IRRI or the CIMMYT, which seemed at one point a real possibility.

Interestingly, despite its international isolation because of the PRC, the AVRDC served as a vehicle for cross-strait agricultural science. In 1970, the success of IR-8 as part of the Green Revolution in Asia reportedly prompted PRC officials to seek some of the seed. An article in the *Times of India* on February 19, 1970, claimed that the People's Republic of China had placed orders for IR-8 by proxy, via Nepal and Pakistan. The article also correlated these reports of IR-8 imports with increases in rice yields reported that year, though the report was wrong in stating that dwarf strains "have not been developed by Chinese geneticists, who, like their counterparts in Russia, still have a long way to go before they come abreast of the latest seed technology in the West," as Chinese scientists had been planting semi-dwarf varieties in the years before the development of IR-8.[99] The acquisition of IR-8 by the PRC caught the attention of development officials in Taiwan, including Shen Zonghan, whose own personal records of this included a handwritten note accompanying a report from Zheng Deci highlighting rumors of the PRC acquiring IR-8.[100]

Later, the establishment of the AVRDC Outreach Program in Thailand allowed for further engagement with the PRC. Thailand Outreach Program director Charles Y. Yang (楊又迪, Yang Youdi), visited the PRC along with AVRDC director Wilbur Selleck.[101] These visits continued in 1982 and again in 1984, when mung bean varieties collected throughout China were sent to the Thailand regional center for evaluation.[102] The Thailand center during this period began to accept training of PRC scientists and technicians where the AVRDC, headquartered in Taiwan, could not accept PRC visitors due to the political circumstances of the Cold War. One such program sent Chinese scientists to Kasetsart University in Thailand for an AVRDC training course on legumes. Another, funded by the Canadian International Development Center, sent over one hundred Chinese scientists to the Thailand center for training in mung bean evaluation and selection. By 1988, Chinese scientists constituted the largest national origin of trainees graduated from the Bangkok Regional Training Center.[103]

In 1984, the AVRDC had initiated projects in collaboration with China in a number of tropical vegetables: tomato, sweet potato, soybean, mung bean, and Chinese cabbage. The goals of these projects were in line with the standard mission of the AVRDC, which is "to improve yields and quality" of the vegetables, "strengthen the expertise of Chinese scientists," assess damage due to plant disease, and collect local varieties in China to bring back to the AVRDC.[104] Yang described encouraging officials within the Chinese Academy of Agricultural Sciences and the Ministry of Agriculture, Animal Husbandry, and Fisheries to increase Chinese scientists sent to training courses and conferences abroad, in Thailand and the Philippines, and to increase the number of international scientists visiting China.

In terms of seed, Yang dedicated much of the report to graphs and charts comparing the yields of AVRDC-selected varieties in mung bean (in Chengdu seeing an average increase of two tons per hectare) and in tomatoes (in one case in Nanjing, outperforming the highest yielding local variety by 522 percent) to local varieties grown throughout China. Yang concluded that AVRDC varieties showed a "very significant impact on the agriculture in the People's Republic of China is in the making" with "enthusiasm expressed by both the research scientists and the lay farmers in seeking for AVRDC's materials."[105] Not all varieties outperformed local varieties—soybeans planted in Xuzhou, for example, underperformed in both total yield and seed size—but nonetheless Yang indicated a silver lining in the possibility to breed in new genetic traits, specifically in resistant to soybean mosaic virus and in good branching character, at the Chinese Academy of Agricultural Science Oil-Seed Crop Research Institute in Wuhan.

Yang remarked that Chinese officials were highly receptive to efforts to work more closely with the AVRDC and indicated this was “facilitated by the trend in Chinese agricultural policy favoring an economic-oriented research and production approach.”[106] In comparison to the socialist agricultural science and scientific farming in the PRC under Mao, the 1980s marked a turn away from science as revolution or mass participation, which was a hallmark of socialist scientific farming.[107] The shift to economic-centered and production-centered policies also meant looking outward and re-engaging global networks that were stronger during the pre-1949 era. As historian Sigrid Schmalzer had argued that the pre-reform era was a careful balancing of *tu* (土, meaning native and indigenous, implying the local knowledge of farmers and of mass participation) and *yang* (洋, meaning foreign, implying the elite knowledge of Western science and of ivory-tower research centers), the post-reform era returned to the embrace of *yang* science, through training courses and foreign selected high-yielding seeds. This convergence after decades of divergence mirrored the larger economic development histories of Taiwan and China, which saw a similar and much more well-known reconvergence via Taiwanese business investment and offshoring to the PRC.[108]

CONCLUSION

In a transition reflective of the agricultural development field as a whole, agricultural science, and specifically Green Revolution sciences that produced high-yielding seeds and chemical fertilizers, became emblematic of the Taiwan’s international development in the 1970s. Seeds and fertilizers were complemented by concern for nutrition, as the basic food problem began to be conquered with increased self-sufficiency among staple crops of Global South countries. As a result, minerals, vitamins, and protein came to the foreground as desirable development goals, and vegetables represented a healthy diet as opposed to just a calorically sufficient one.

Taiwan attempted to capitalize on this shift toward nutrition and food. After its ouster from the UN, the Taiwanese government turned to the FFTC and the AVRDC as institutions to maintain international relevancy. Taiwanese planners imagined vegetables and fertilizers as the new frontier at which it could occupy the vanguard. They could secure Taiwan’s international position as agrarian development missions to Southeast Asia and Africa did a decade earlier. Taiwanese bureaucrats and scientists hoped that the technical nature of agricultural science could transcend the geopolitics of international recognition that began to plague Taiwan. They were ultimately mistaken.

By the late 1970s, the Green Revolution had reached its apex, and practitioners began to move away from its associated methods. The 1962 publication of Rachel Carson’s *Silent Spring*, which showcased the dangers of pesticides and agricultural chemicals, spurred an environmentalist movement that began to erode Green Revolution chemical dependence.[109] In 1979, Robert McNamara, president of the

World Bank, announced that World Bank loans would be made contingent on recipient nations adopting World Bank–imposed policy changes. This policy of structural adjustment lending, which often forced policies of open markets and austerity policies that negatively affected developing nations, was also shared by the International Monetary Fund and became the preponderant development philosophy of both Bretton Woods institutions in the 1980s.[110] Vegetables garnered less interest compared to structural adjustment lending. Even in the agricultural development field, vegetables were outshone by rice and wheat. The Taiwanese pushed for the importance of vegetables given the increasing attention on nutrition instead of calories as an emerging standard by the 1970s, but vegetables still lacked the allure of staple crops. After the Republic of China left the United Nations in 1971, its efforts to join international groups like the CGIAR were frustrated by its lack of official international status. Neither the FFTC nor the AVRDC ever received international funding that the CGIAR institutions had gained because of Taiwan's geopolitical status. Instead, the FFTC and the AVRDC remained small, underfunded, and by the 2000s, hollowed-out versions of their 1970s ambitions.

As Taiwan in the 1980s achieved increasing international attention for its tremendous export success from manufacturing shoes, bicycles, dolls, and later, electronics and semiconductors, few noticed the decline of agricultural science. Export processing zones, science and technology parks, industrial research, and contract manufacturing became the new scientific frontiers for Taiwan in the 1980s and 1990s. The heyday of Taiwanese vegetables, if there ever was one, was over. It was instead consumer goods and the nascent electronics industry that provided Taiwan with the international relevancy it had earlier sought in agriculture. In eclipsing agriculture, the rise of Taiwan's industrial strength marked the decline of international agrarian development.