

Embedding Technologies into the Farming Economy: Extension Work of Japanese Sugar Companies in Colonial Taiwan

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Abstract This article examines the extension of cultivation technologies by Japanese sugar companies in colonial Taiwan during the 1910s. As it became necessary for them to price their sugar more competitively in a Japanese market that by the end of the 1900s had become oversupplied, and with the devastation wrought to sugarcane cultivation by severe storms, from the early 1910s sugar companies accelerated their efforts to extend technologies to sugarcane farmers. However, such attempts faced difficulties at first because of the economic conditions at the time and also because of conflict with the production system managed by each farming household, which was characterized by multiple farming, crop rotation, and a circular economy. Realizing the deficiencies in extending the technology, Ensuikō Sugar began to reform its work from the mid-1910s so as to win the hearts of the farmers by reorganizing the hierarchy involved in the extension efforts. The company also redesigned the components of its extension work by taking account of the economy of Taiwanese farmers. This article observes the beginning of the incorporation of the farming economy into a system of agricultural technology, in which the power involved in technologies gradually permeated the daily lives of farmers.

Keywords Japanese colonialism · sugarcane · extension work · environmental history of technology · technological system

Abstract 本稿では、日本統治期台湾の製糖会社による甘蔗栽培技術の普及事業について検討する。日本内地市場における砂糖供給の過剰問題と、暴風雨による甘蔗作の大規模な被災をうけて、1910年代初頭の台湾島内の各製糖会社は甘蔗耕作者への栽培技術普及事業を拡大した。しかし、その試みは甘蔗栽培に不利であった同時期の経済条件と、多角経営・輪作・循環経済を特徴とする耕作者の農業生産システムと衝突することによって、早々に不調に陥った。これに対して、1910年代半ばの塩水港製糖は、(1)技術普及事業の指揮系統を耕作者の積極的な技術受容を引き出しやすい形に再構築し、

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さらに（２）普及させる栽培技術の内容について耕作者の経営を考慮して修正・妥協することにより、技術普及の円滑な進展を目指した。1910年代の技術普及をめぐる以上の曲折を検討することで、日本統治期台湾の耕作者の経営が技術システムに取り込まれていく端緒が明らかとなる。

Keywords 植民地統治・サトウキビ栽培・環境史・技術普及・技術システム

This article tells the story of the extension of cultivation technologies by Japanese sugar companies in colonial Taiwan during the 1910s and the conflict between these technologies and the production system managed by each Taiwanese farming household.¹ From the early years of the occupation, Japan supported the development of the sugar industry and sugarcane cultivation in Taiwan, as did other Great Powers in their own tropical colonies. Because of their considerable influence and their harsh exploitation of the farmers, Japanese sugar companies became one of the main targets of Taiwanese social resistance, and they are remembered by Taiwanese today as one of the most notorious actors of the colonial era; this is why the sugar industry has been the main focus in the study of Japanese imperialism.

By tracing its interactions and conflicts with the Taiwanese farmers, this article explores the processes that made extension work (*gijutsu fukyūjigyō* 技術普及事業) by sugar companies appealing to these farmers.² From the early 1910s, Japanese sugar companies in Taiwan, faced also with the devastating damage done to cultivation by severe weather in 1911 and 1912, accelerated their efforts to extend cultivation technologies in order to reduce the production costs of sugarcane. Yet they faced difficulties: economic conditions were very bad, and there were both shortcomings in the extension work itself and conflicts with the production system managed by each farming household, characterized as it was by multiple farming, crop rotation, and a circular economy. In realizing the deficiencies of the extension work and the serious conflicts with the farmers' production system, from the mid-1910s onward sugar companies began to reform their extension work so as to win over the farmers. On the one hand, they reorganized the hierarchy involved in extension work so that it more effectively conveyed the company's policy to the local level; on the other, they also began to design the components of the extension work that took into account the economy of the Taiwanese farmers. Although these new attempts in the 1910s had limitations, they heralded the further development of extension work and improvement of unit yields after the 1920s.

This trajectory, with the many twists and turns in the sophistication of the extension work done by Japanese sugar companies, is worth dwelling on for several reasons. First, it requires us to pay more attention to the mutual interaction with society involved in the tailoring of technological policy. Attention to this dynamic allows us to adopt the systems approach developed by the historian [Thomas P. Hughes \(1983\)](#), which focuses

¹ Throughout this article, I use *cultivation technologies* in a broad sense, indicating not only the use of artificial fertilizers or selected buds but also such techniques as weeding, plowing, leveling, and coordinated crop rotation. The purpose of the extension work done by sugar companies was to introduce these various cultivation technologies to Taiwanese farmers.

² I romanize Japanese using the Hepburn system, and Chinese using pinyin.

on the interaction of a technological system with politics, law, economy, and society. In his study of electrification in the United States, England, and Germany, Hughes found that successful inventors such as Thomas Edison also played the role of entrepreneur: Edison not only invented his lighting system but also concerned himself with the costs of generating and distributing electricity and with financial and political matters. This perspective is particularly significant in historiographies of colonialism, where the impact of the science and technology introduced by colonizers is often discussed deterministically. Such an analysis can typically be seen in [James Scott's 1998](#) study, which points out the high-modernism approaches in the technological policies of authoritarian regimes that emphasize the power of science and technology to transform society. Recent studies of European imperialism have, however, criticized such studies as Scott's, pointing out the tailored aspects of technological policy and scientific investigation instigated by colonial officials. For instance, [Suzanne Moon \(2007\)](#) has argued that Dutch agricultural engineers in Java in the 1910s became convinced that tailoring to local ecological and social conditions was necessary for the successful breeding of rice. [Helen Tilley \(2011\)](#) also found that European scientists who joined the African Research Survey during the interwar period turned their attention to vernacular knowledge. However, this process of tailoring has rarely been examined in the case of the Japanese Empire, and recent studies on Japanese colonial development projects ([Fujihara 2012](#); [Shimizu 2015](#)) still repeat Scott's approach. One valuable exception is [Aaron Moore \(2013\)](#), who examines dam construction projects in Japanese-occupied Manchuria. Moore discusses the comprehensive dimension of the development policy, focusing on negotiation in the upper tiers of government, including technocrats and engineers. But room still remains for consideration of the interactions between engineers or governments and the inhabitants of a colonial society regarding technological policy. This article focuses on this point by analyzing the extension work surrounding the production system maintained by Taiwanese sugarcane farmers.

To discuss the extension work surrounding this production system is also to break new ground in the field of the agricultural history of colonial Taiwan, as previous work has focused too much on agricultural development via the introduction of new technologies and knowledge ([Myers and Ching 1964](#); [Myers and Yamada 1984](#); [Lee 2009](#); [Tsai 2009](#)). Although Taiwan's production system has been discussed in research into the Qing era ([Tseng 2006](#)) and from the viewpoint of modern environmental conservation, studies of the production system in colonial Taiwan have been surprisingly scarce. This is evidently down to a deterministic view of the introduction of technology and knowledge in the colonial period, so we should instead move our focus from the introduction of technology to the production system, managed by farmers, within which the technologies were embedded. When we do so, the 1910s emerge as a key period, as it was from this point on that Japanese engineers made greater efforts to extend knowledge and technologies to the local level and to find ways to embed them into the farming economy. This period has been ignored in previous studies of Taiwanese agricultural history, since much new knowledge and technology had already been introduced from Japan in the 1900s, while productivity in important crops, including sugarcane and rice, did not improve in the 1910s as it would in the 1920s. However, it is only by analyzing extension work and its limitations in the 1910s, faced as it was with the production system maintained by farmers, that we can precisely ascertain the

impact of the introduction of technology in the 1900s and understand the background to the improvements in productivity in the 1920s.

By providing a contrast with the seizure of land and the manipulation of sugarcane prices, which are often understood as forms of colonial despotism, the sugar companies' domination of the industry that Taiwanese farmers experienced in the period also emerges in greater relief. Although Ka Chih-ming (1998) showed the dependency of Taiwanese sugarcane farmers on the market that came about through the introduction of commercialized technologies such as new varieties of bud, irrigation, and fertilizer, his point seems to be in danger of missing the impact on and the threat posed to the production system run by the Taiwanese farming households. As sugarcane cultivation was embedded in the production system, the introduction of technologies into sugarcane cultivation could have brought about not only dependence on the market but also a thorough transformation of the system as a whole, including the daily lives of each household. This challenge to that system is the focus of this article, which analyzes the extension work done by sugar companies in the 1910s.

This article relies on three kinds of historical documentation. The first is the published statistics and annual reports edited by the bureaucrats of the governor-general's office, the most basic materials for the analysis of Taiwanese economic history. Second, for more regional and detailed analysis, are reports written by the engineers of the Agricultural Association of Kagi Prefecture (Kagichō Nōkai 嘉義庁農会) (AAKP) and the sugar companies, which provide rich accounts of the local situation regarding sugarcane cultivation. These reports are located mainly in the National Taiwan University Library and the National Library of Taiwan. Third are reports written by managers of the Bank of Taiwan, held in the Bank of Taiwan Collection, which has recently been opened to the public by the Institute of Taiwan History Archives, Academia Sinica. Since most of these accounts were written by Japanese bureaucrats and engineers, sources that directly document the perspectives of Taiwanese farmers are lacking. Nevertheless, one can deduce that Taiwanese perspective by carefully sifting through the official materials to identify traces of those farmers' voices.

1 Oversupply in the Homeland Sugar Market and the Damage Done by Storms

Japanese sugar companies in Taiwan began to extend cultivation technologies from the early 1910s. Although the sugar industry developed quickly to become the principal industry of Taiwan, owing to the considerable support given by the governor-general's office, no sooner had Japanese companies successfully laid the foundations in the 1900s than they faced severe problems in the market and in the cultivation of sugarcane. As supply began to outstrip demand in the homeland sugar market at the end of the 1900s, it became necessary for sugar companies in Taiwan to make their product more competitively priced. Also, severe weather in 1911–12 caused devastating damage to sugarcane cultivation. These problems led sugar companies to reflect on past cultivation methods and to make more of an effort to extend cultivation technologies to farmers. This section discusses this process in detail as the background to analyzing the extension work done in the 1910s, first briefly focusing on the development of the sugar industry in Taiwan in the 1900s.

Japan colonized Taiwan in 1895, after the First Sino-Japanese War, and soon the Japanese government and its local agency, the governor-general's office, began to support Japanese capital investment in the sugar industry. The Japanese government did this so as to become self-sufficient in sugar; at the time it was largely dependent on foreign sugar imports and suffering from a huge outflow of foreign currency (Tōgyōkyōkai 1962: 277; Tu 1975: 62). The island's sugarcane yield, just 700 million *kin* (斤) in 1902, rose to over 4.7 billion *kin* in 1910 (Shokusankyoku Tokusanka 1926: 1), by which time most of the sugar manufactured was being exported to the Japanese homeland.³ The sugar industry was the symbol of Japanese colonization of Taiwan both in name and in reality. The Japanese government protected Taiwanese sugar in the homeland market by imposing tariffs on foreign sugar (Tu 1975: 66–67). There were also several forms of support from the governor-general's office to the sugar companies, the most important being the 1905 “system of exclusive territories for cane procurement” (*saishukuiki seido* 採取区域制度) (Ka 1998: 79), by which the companies could reduce the purchase cost of sugarcane bought from the Taiwanese farmers. As each farming household possessed its own land, with few plantations of the sort often seen in colonies such as Cuba and Hawaii, sugar companies could not be certain of purchasing sugarcane cheaply. The system of exclusive territories, however, allocated a territory to each sugar manufactory, which exclusively purchased the sugarcane produced there. Although under this system Taiwanese farmers could still choose what they cultivated, they were forced to sell any sugarcane they grew to the company to which their land was tied (Ka 1998: 110–13). Through a substantial monopoly over their allotted regional market, therefore, Japanese sugar companies could reduce the purchase price by reducing the bargaining power of the Taiwanese farmers.

With other subsidies and the support of the police, from the second half of the 1900s onward more and more Japanese sugar capital established huge factories on the island, replacing the small, native sugar mills, and soon the industry developed (Ka 1998: 79–80). In 1910 there were already seventeen modern sugar factories owned by ten companies. Among them, Taiwan Sugar (台湾製糖) was the largest, with six factories. Other Japanese companies, such as Dai-Nippon Sugar (大日本製糖), Meiji Sugar (明治製糖), Ensuikō Sugar (塩水港製糖), and Tōyō Sugar (東洋製糖), were also so large that each was capitalized at more than five million yen and could process more than eight hundred tons per day (Shokusankyoku Tōmuka 1916: 10–11). Under the tariff protection of the Japanese government and the support of the governor-general's office, these companies steadily expanded their capital base and increased their profits (Tōgyōkyōkai 1962: 325–26; Tu 1975: 68–69).

Nevertheless, as early as the end of the 1900s the sugar industry in colonial Taiwan faced a bottleneck with the oversupply in the Japanese homeland sugar market. The type of sugar produced in Taiwan was brown, mostly exported to the homeland market for direct consumption (Hirai 2007: 34). The problem was that sugar consumption in the homeland was at most 1.5 million piculs (1 picul = 60 kilograms) each year from the end of the 1900s through to the first half of the 1910s, but the supply from Taiwan exceeded this substantially from the end of the 1900s (table 1). And so sugar companies in Taiwan were forced to look for new markets. It was unprofitable to export

³ 1 *kin* = 600 g.

Table 1 Supply of Taiwan Sugar and Consumption in Japan, 1907–14 (in piculs)

Year	Supply of Taiwan Sugar			(4) Consumption of Direct-Consumption Sugar	Surplus (3) – (4)
	(1) Total Supply	(2) Raw Sugar	(3) Direct-Consumption Sugar [(1) – (2)]		
1907	426,020	0	426,020	1,115,655	–689,635
1908	990,981	0	990,981	875,229	115,752
1909	2,015,716	0	2,015,716	1,140,520	875,196
1910	1,844,699	285,446	1,559,253	1,502,505	56,749
1911	2,768,608	1,405,322	1,363,286	1,442,951	–79,665
1912	2,061,728	802,335	1,259,393	1,393,617	–134,224
1913	949,012	146,738	802,274	1,359,477	–557,203
1914	2,020,606	929,583	1,091,023	967,100	123,924

Source: Adapted from Hirai 2011: 67. Data sources: Nōshōmushō Nōmukyoku 1919: 35; Yamashita 1931: 12; Zaimukyoku 1936: 504–507; Seitō Kenkyū kai 1937: 95.

overproduced Taiwanese sugar to countries such as China because Javanese sugar, which had preceded Taiwanese sugar in the East Asian market, was much cheaper because of Java's more favorable environmental conditions, its developed irrigation system, and its lower wage costs (Tōgō 1913: 63). From 1910, Japanese sugar capital in Taiwan had to enter the raw sugar market in the homeland, where it was used for manufacturing refined sugar, but this too was problematic, as Javanese sugar had preceded the Taiwanese and was also popular in the Japanese raw sugar market (Tōgyōkyōkai 1997: 3; Hirai 2007: 34). As a result, sugar companies in Taiwan had to price their sugar more competitively in the homeland market to compete with the Javanese product, even though Taiwanese sugar was protected by tariffs.⁴

Severe storms in the summers of 1911 and 1912 caused devastating damage to sugarcane cultivation in Taiwan (Kubo 1997: 124–26), sharply reducing the total harvest to 1.5 billion kin in 1912, just one-third of what it had been in 1910. It was only after 1915 that the harvest recovered to pre-1911 levels (Shokusankyoku Tokusanka 1926: 1). The storms also resulted in a lack of suitable sugarcane buds to distribute to the farmers for planting the following season, and several plant diseases became widespread as sugar companies distributed buds indiscriminately (Tōgyōkyōkai 1997: 48). To make matters worse, after the storms sugar companies turned to importing large quantities of buds from foreign producers, and plant infections such as pineapple disease and downy mildew were imported and spread to the sugarcane fields in the southern part of Taiwan (Shokusankyoku 1913: 598–609, 1919: 1–4). The severe damage caused by the storms led Taiwan's sugar companies to reflect on the methods of sugarcane cultivation they had used until then (Tōgyōkyōkai 1997: 60).

Sugar companies dealt in various ways with the very difficult situations in which they found themselves. First, in 1910 they organized a cartel (Tōgyō Rengōkai 糖業聯

⁴ As Hirai (2007: 34) showed, though the production cost of Taiwanese brown sugar was ¥7.2, and the selling price of sugar for direct consumption was between ¥11 and ¥13, raw sugar was being sold at ¥10.5 in 1915.

合会) to adjust and allot the amount of raw sugar and of sugar for direct consumption that each produced. Their cartel was also intended to increase their bargaining power against sugar-refining companies in the Japanese homeland, especially Dai-Nippon Sugar, to avoid a drop in the price of Taiwanese brown sugar because of oversupply (Tōgyōkyōkai 1997: 5–6). Second, mergers and acquisitions among Japanese sugar companies occurred in the first half of the 1910s (Tu 1975: 293); Chūō Sugar (中央製糖), for instance, merged into Meiji Sugar, and Horisha Sugar (埔里社製糖) merged into Taiwan Sugar. Meiji Sugar and Taiwan Sugar also merged with sugar-refining companies in the Japanese homeland in 1911 and 1912, respectively, which increased their bargaining power against Dai-Nippon Sugar (Tōgyōkyōkai 1997: 15). In addition, sugar companies started to select the variety of sugarcane and to breed buds, especially after the latter half of the 1910s, when the governor-general's office instructed companies to construct their own nursery gardens (Tōgyōkyōkai 1997: 56–57). Moreover, sugar companies made greater efforts to improve methods of sugarcane cultivation by farmers through extension work. Because the production costs of the sugarcane accounted for 50–60 percent of the overall production cost of the sugar (Shokusankyoku Tokusanka 1926: 94), and because it was impossible for Japanese sugar capital to simply reduce the purchase price of sugarcane bought from the Taiwanese farmers without running the risk that many of them would give up planting it, improvements in sugarcane cultivation were expected to reduce production costs by raising the unit yield and therefore price their sugar more competitively (Shokusankyoku 1914: 36–38). The devastating damage wrought by storms on the cane fields also forced sugar companies to improve the means of cultivation (Itō 1939: 182–89; Tōgyōkyōkai 1997: 51, 60). Again, because it was difficult to lead farmers to improving their cultivation practices, companies repeatedly petitioned the government for permission to requisition farmers' land or to force them to plant sugarcane, though these petitions always failed.⁵

Among these policies, the one most immediately related to the lives of the farmers, and upon which this article focuses, was the expansion of the extension work for the technological improvement of sugarcane cultivation. Improvement of cultivation technologies had not been an important subject for Japanese sugar companies before the 1910s, as they had concentrated more on encouraging farmers simply to increase the acreage under cultivation. Though new varieties of sugarcane imported from Hawaii and Java spread successfully on Taiwan, progress in the use of commercial fertilizers, cultivation methods, irrigation, and so on, was limited during the 1900s (Hirai 2012: 36–37). Needing to reduce production costs, and faced with storm damage to sugarcane cultivation, from around 1910 Japanese sugar companies accelerated their attempts to raise yields by directing farmers toward intensive farming of sugarcane, extending new cultivation technologies (Shokusankyoku 1914: 36–38).

Support from the governor-general's office for extending cultivation technologies was limited (Hirai 2015: 197–98). Although there had been some subsidies, they decreased sharply through to the mid-1910s (Shokusankyoku Tokusanka 1926: 112–13), partly due to rising public suspicion in Japan over the future prospects for the

⁵ Historical records for these petitions can be found in the Historical Records Collection of Industrial and Economic Relations in Colonial Taiwan (Shokuminchiki Taiwan Sangyō Keizai Kankeishiryō 植民地期台湾産業・経済関係史料) in Tōgyōkyōkai. The petitions were one of the subjects of the 135th and 197th meetings of Tōgyō Rengōkai.

Table 2 Average Production Cost of Sugarcane Sugar Manufactories: 1909–26 (in yen/picul)

Year	(1) Purchase Cost	(2) Material Charges	(3) Production Cost [(1) + (2)]	Material Charges as Percentage of Production Cost $[(2)/(3)] \times 100$
1909–1910	2.382	0.397	2.779	14.3%
1910–1911	2.223	0.432	2.655	16.3%
1911–1912	2.530	0.803	3.333	24.1%
1912–1913 ^a	3.209	1.352	4.561	29.6%
1913–1914	2.662	1.248	3.910	31.9%
1914–1915	3.361	1.122	4.483	25.0%
1915–1916	3.182	0.956	4.138	23.1%
1916–1917	3.257	0.933	4.190	22.3%
1917–1918	3.861	1.309	5.170	25.3%
1918–1919	5.146	1.683	6.829	24.6%
1919–1920	8.289	3.155	11.444	27.6%
1920–1921 ^b	7.088	3.507	10.595	33.1%
1921–1922	5.844	2.571	8.415	30.6%
1922–1923	5.521	1.651	7.172	23.0%
1923–1924	4.726	1.929	6.655	29.0%
1924–1925	5.017	2.049	7.066	29.0%
1925–1926	4.994	2.124	7.118	29.8%

Source: *Shokusankyoku Tokusanka* 1928: 102.

^a Production costs in 1912–13 were higher owing to the damage of severe storms in the previous two years.

^b The data for 1920 are an average of nine main sugar companies.

industry, given that oversupply and the risk of storm damage were both considered hard to solve (Miyagawa 1913: 12–24). In addition, bureaucrats of the governor-general's office thought that the sugar industry had developed to the extent that other crops, such as potatoes, wheat, and beans, could begin to be given more importance (*Shokusankyoku* 1912: 5–6; *Shokusankyoku Nōmuka* 1913). The position of the sugar industry within industrial development policy declined somewhat, relative to what it had been in the 1900s.

Japanese sugar companies, then, were on their own when it came to extending the new cultivation technologies to Taiwanese farmers. The companies' efforts can be seen in table 2, which shows the variation in the average production cost of sugarcane by modern sugar factories in Taiwan. The purchase cost is the money paid by sugar companies to purchase sugarcane from the farmers. Note the variation in material charges, nearly half of which consisted of incentives given by companies to farmers to encourage them to introduce new technologies.⁶ Not only did the amount of material charges clearly increase after 1911, but their percentage within the average production costs also increased by nearly 10 percent, indicating that sugar companies began to put more effort into extension work.

⁶ The rest of the material charge consisted of transportation fees, harvesting costs, and wages for company officials. Taishōkyūnenki Kakushinshikiseitōkaisha Seisanhichō 大正九年期各新式製糖会社生産費調 (Report on the Production Costs of Sugar Companies in 1920), Nakase Papers, Historical Records Collection of Industrial and Economic Relations in Colonial Taiwan (*Shokuminchiki Taiwan Sangyō Keizai Kankeishiryō* 植民地期台湾産業・経済関係史料), Tōgyōkyōkai.

Extended technologies for improving unit yields consisted of many successive and interlinked elements, but sugar companies made use of artificial fertilizers a priority. Cultivation technologies started with preliminary work, such as plowing and harrowing, and continued with the planting of buds, weeding, tilling between the rows of cane, ridging, the plowing in green manure, and of course, fertilizing. Last of all came the harvesting, and farmers were sometimes advised to exterminate harmful insects by hand (Sugai 1911; Miyagawa 1913: 82–96). Scientific bud selection and the construction of irrigation works were kept separate from these activities, as they were obviously too difficult for any one household to address. Sugar companies conducted bud selection in their own nursery fields in cooperation with the governor-general's Sugar Experiment Station (Tōgyōkyōkai 1997: 51–60).

As it became necessary for sugar companies in Taiwan to price their sugar more competitively in a Japanese market, which by the end of the 1900s had become oversupplied, and with the devastation wrought to sugarcane cultivation by severe storms, from the early 1910s Japanese sugar companies expanded their extension work for technological improvement. However, changing the cultivation methods used by Taiwanese farmers was no easy matter, despite the sugar companies providing more incentives than before. This difficulty during the 1910s has been completely ignored in previous studies of agricultural technology transfer in colonial Taiwan, which have focused too much on agricultural development through the introduction of new technologies and knowledge and have assumed its success in a rather simplistic manner. In fact, it is only through analyzing this difficulty, and the process of resolving it, that we can precisely ascertain the impact of the introduction of technologies.

2 Difficulties in the Extension Work

2.1 Economic Conditions and Incentives

Japanese sugar companies faced immediate difficulties when in the early 1910s they accelerated their attempts to spread new cultivation methods. This section discusses the problems of the extension work in detail, mainly looking at the case of Kagi Prefecture (Kagichō, 嘉義庁), in the vicinity of present-day Jiayi. In the mid-1910s, the prefecture included eleven modern sugar manufactories, together producing nearly ten thousand tons of sugarcane per day, owned by five sugar companies: Tōyō, Ensuikō, Dai-Nippon, Meiji, and Nītaka. More than twenty-eight thousand *kou* (甲) were devoted to sugarcane in the prefecture, which in 1914 accounted for 37 percent of Taiwan's total (Shokusankyoku Tōmuka 1916: 18–19),⁷ with Kagi the largest center for sugarcane production. Table 3 shows data on annual sugarcane cultivation in Kagi prefecture in the first half of the 1910s. One can see the variation in unit yields, caused by storm damage in 1911 and 1912, which considerably decreased sugarcane acreage and yields. But these data do not show all of the difficulties involved in extension work in this period, so we need to look to other historical records. Although only a limited account on the extension work at the coalface survives, this can be accessed thanks to the detailed

⁷ 1 *kou* = approx. 0.97 hectares.

Table 3 Annual Production of Sugarcane in Kagi Prefecture: 1908–15

Year	(1) Sugarcane Acreage (kou)	(2) Yield (kin)	Unit Yield [(2)/(1)]
1908	9,506.08	542,459,540	57,064
1909	11,663.79	746,547,257	64,006
1910	23,972.69	1,255,471,146	52,371
1911	34,712.88	1,663,030,492	47,908
1912	29,637.61	1,332,094,403	44,946
1913	26,219.48	531,629,501	20,276
1914	28,371.52	815,993,700	28,761
1915	30,540.45	1,451,397,411	47,524

Source: *Shokusanjyoku Tōmuka 1918: 24–25.*

reports written in the 1910s by the engineers of the Agricultural Association of Kagi Prefecture (AAKP). These accounts are currently located at the National Library of Taiwan and National Taiwan University in Taipei. As the AAKP engaged not only in sugarcane cultivation but also in farming as a whole, including cultivation of rice and potatoes, these reports, although they belonged to the governor-general's office, sometimes provide critical observations on the sugar industry.

The fact that sugar companies in Kagi Prefecture in the first half of the 1910s had trouble with extending technologies can be observed through the typical case of the extension of commercial fertilizer, one of the core aspects of the improved cultivation of sugarcane. Most of the artificial fertilizer used in Taiwan by sugarcane growers in this period was the mixed fertilizer sold by each regional sugar company. On the initiative of the sugar industry section of the governor-general's office, under a system called “cooperative purchase” (*kyōdō kōbai* 共同購買) (Hirai 2012: 38, 44), sugar companies bought from fertilizer manufacturers or merchants and sold to farmers at below-market rates to encourage them to use fertilizer. Even so, sugar companies were unable to achieve favorable results. Ohara Issaku (小原一策), an assistant engineer in the AAKP, presupposed in his report that good sugarcane farmers used at least ¥60 worth of fertilizer per kou, but in no more than 5 percent of the areas under sugarcane cultivation were sufficient amounts of fertilizer used (Ohara 1915: 99–100).⁸ According to Suenaga Megumu (末永仁), another assistant engineer in the AAKP who is today famous for his successful breeding of Hōrai rice (蓬莱米) in the 1920s, average use in 1914 was as little as ¥21.6 per kou (Suenaga 1915: 52). What kind of difficulties did the extension work face to cause it to be so unsuccessful?

It was certainly due in part to the arrogant manner of the extension workers employed by the sugar companies. Extension work was regarded by companies as a way to “civilize” Taiwanese farmers, who were often treated contemptuously. We can observe such a manner in a comment by Takagi Tetsuo (高木鐵男), one of the Japanese directors of Meiji Sugar, who in 1914 said to Fujimoto Natsuo, the Tainan branch manager of the Bank of Taiwan, regarding an investigation into the business conditions for sugar companies for funding, “We have already found what kind of technology is necessary

⁸ In writing Japanese and Taiwanese names, I place the family name before the given name.

for improving cultivation, but we still have no idea how to extend it among the farmers. We have trouble with breaking the customs of uncivilized people [*dojin* 土人]” (Fuji-moto 1914b: 26). Recent studies have showed that, although Japan justified its colonialism by promoting civilization through the introduction of a modern infrastructure, knowledge, and technologies, which to a considerable extent were previously lacking in Taiwan, the Taiwanese people took an ambivalent attitude toward these changes (Chen 2001). It was obvious that Takagi assumed that increasing the unit yields of a farmer’s field through extension work was a way of civilizing “uncivilized” Taiwanese farmers. It also seemed unavoidable that many farmers would be far from positive about the extension of technologies, particularly when such changes were promulgated in such a haughty way by Japanese colonizers faced with language barriers (Oda 1915: 151).

However, there were much more fundamental problems with the extension work. One was that, in the first half of the 1910s, external conditions were not conducive to companies carrying out extension work. This was partly due to the widespread damage to sugarcane cultivation caused by the storms of 1911 and 1912, which made the farmers less inclined to grow sugarcane, but the increase in rice prices in the period was also crucial. Rice was sugarcane’s most important competitor crop in Taiwan, and the price of unpolished rice remained high: between ¥5 and ¥6 in 1911–14, though it had mostly remained under ¥4 in the latter half of 1900s (Shokuryōkyoku 1942: 86–87). As a result, according to an analysis by AAKP assistant engineer Miyamoto Shōji (1915: 157–61) of the data on the farming of each crop from late 1912 to early 1913, it was difficult to obtain more profit from growing sugarcane than from paddy rice, even if the unit yield of sugarcane exceeded 80,000 kin, when the average in Kagi Prefecture was at most 52,000 kin in the first half of the 1910s (Shokusankyoku Tōmuka 1918: 24–25). Favorable economic conditions for rice cultivation reduced the incentive for farmers to choose to grow sugarcane and to invest capital and labor in it, if their fields could be used as paddies (Sagara 1918: 17). In fact, it was not even guaranteed that farmers could reap more profit from sugarcane than from other dry-field crops such as potatoes, beans, upland rice, and so forth. Profits from sugarcane could possibly exceed other crops when the unit yield was more than 50,000 kin (Miyamoto 1915: 157–61), which was still much higher than the average in Kagi Prefecture in 1913 and 1914. This all indicated that it was necessary to improve the path toward sugarcane cultivation by investing a certain amount of capital and labor, as recommended by the companies, if farmers hoped to earn more profit than through cultivating other crops. On the other side of the equation, the risk of large losses in sugarcane cultivation was higher than for other crops, as the cultivation period for sugarcane was lengthy—sometimes more than a year. It was unavoidable that cane fields would often be damaged by natural disasters, such as summer storms (Suenaga 1913: 25), and losses would be much larger if farmers had invested intensively in sugarcane. By contrast, other dry-field crops were usually cultivated with relatively little investment, so there was a smaller risk of large losses, though profits were not as high as those possible through successful cultivation of sugarcane with a considerable amount of investment (Miyamoto 1915: 157–61). It was undeniable that the uncertainty of profits in sugarcane cultivation and the high risk of large losses became barriers for farmers to decide on investing in sugar and introducing the technologies extended by sugar companies.

Faced with these severe economic conditions, sugar companies did not stand by idly, of course, but there were apparent limitations to what they could do. As greater

incentives were necessary to appeal to farmers to introduce new cultivation technologies, sugar companies not only raised the average purchase price of sugarcane but also raised the subsidy for farmers to introduce cultivation technologies (table 2). However, it was impossible for companies to raise the subsidy so high that production costs could not be decreased, because this was the very aim of their extension work. Moreover, the problems of uncertainty of profit and the high risk of large losses remained for the farmers, even if companies did raise the purchase price and subsidy. Because farmers often had trouble acquiring sufficient amounts of cash (Kajiwara 1923: 145), the risk problem could not easily be solved by increasing incentives.

Incentives provided to farmers were reduced by certain shortcomings in the extension work itself during the 1910s. Primarily, sufficient human capital for extending technologies was lacking. As most officers and extension workers in the field had never received any regular education in modern agronomy, they were not particularly familiar with the extended technologies. This was mainly because the primary task of the sugar companies in the 1900s was not extension work but instead simply encouraging farmers to increase the area under sugarcane cultivation (Hamaguchi 1959: 53; Hirai 2015: 194). Ohara, who graduated from the Agricultural School of Kumamoto, vividly described the situation in the 1910s, observing that “extension workers who have enough knowledge and technique to gain respect from the farmers are as few as the stars in the dawn sky. Only shallow imitation is what most of them can do” (Ohara 1915: 103). As these workers often lacked sufficient knowledge, it was perhaps difficult for Taiwanese farmers to rely on their extension work, even if they were interested in introducing new cultivation technologies to their own fields. Second, the extended technologies were not coordinated well enough with the local environmental conditions in each part of Taiwan. The technologies extended by the sugar companies had been transferred one after another from the homeland, America, and Europe from the 1900s (Tōgyōkyōkai 1962: 289; Wu 2008), but it was not always certain that they could be successfully applied to the conditions in Taiwan. Even if it was possible to use them in Taiwan, some tailoring was necessary in many cases. One example of such a problem concerned the components of artificial fertilizer. The fact that nitrogen, phosphoric acid, and potassium formed the basis of artificial fertilizers was already known in 1900s Taiwan, but the appropriate breakdown of ingredients suitable for each area of Taiwan remained unknown in the mid-1910s (Suenaga 1915: 52–53; Hirai 2015: 189).

So it was under difficult economic conditions that sugar companies began to accelerate their efforts in extension work, and it was unavoidable that there would be many limitations and shortcomings. No wonder, then, that the work could not win over the hearts of the farmers and achieve any remarkable result in the early 1910s.

2.2 Conflict with the Production System Managed by Taiwanese Farmers

The existing production system managed by each farming household also deserves serious consideration. It was critical to the extension work that sugarcane was not cultivated independently but embedded in a system characterized by multiple farming, crop rotation, and a circular economy, and that it contributed to producing a stable profit. But it was this very system that also forced extension work to stagnate. The following discussion looks at how extended technologies conflicted with such a production system.

First of all, the companies' extension work was at odds with the multiple farming practices of Taiwanese farmers, as the latter demanded that farmers disperse a certain amount of their capital and labor for growing other crops and raising domestic animals. According to Tseng Pin-tsang (2006), although sugarcane or rice was a core crop in the economy of each household in Taiwan, under the Qing it was often coordinated with the cultivation of secondary crops, and also with stock raising, fish farming, and fruit growing. This multiple farming continued to be popular in the Japanese colonial era (Suenaga 1913: 32, 1914: 34–35). The conflict between extension work and multiple farming could typically be seen in the fact that farmers sometimes diverted fertilizer (soybean meal) bought cheaply from the sugar company to other crops or to feeding pigs (Ohara 1915: 100; Taiwan Ginkō Sōmubu Chōsaka 1920: 41). Although Hirai (2012: 44, 2015: 178–79) attributed this to the innocence of the farmers, it can also be understood from the viewpoint of the conflict with the multiple farming system. In addition, Suenaga pointed out that Taiwanese farmers took pains over sugarcane cultivation when conditions were favorable but stopped caring once things began to go wrong (Suenaga 1915: 54). Such a flexible attitude can also be understood from the viewpoint of multiple farming, in which farmers needed to make more of an effort on other aspects of their farming portfolio rather than stick to the seemingly unsuccessful cultivation of a certain crop. It is difficult to show what ratio of each household's fields was allotted to each crop and how many stocks were raised by each household on average. According to the agricultural and sugar industry statistics published by the governor-general's office, the area of each household's average sugarcane cultivation was 1.07 kou in 1920,⁹ although the average total area under cultivation was 1.85 kou across the whole island, indicating that nearly 40 percent of cultivated land was allotted to other uses by each household (Shokusankyoku 1921: 24–25; Shokusankyoku Tokusanka 1926: 55). As for seven sample households in Kagi Prefecture, which mainly cultivated sugarcane and were surveyed under the governor-general's basic survey of agriculture (*nōgyō kihonchōsa* 農業基本調査) at the end of the 1910s, everyone cultivated other crops, such as beans, potatoes, dry-field rice, wheat, and vegetables, though some were not cultivated at the same time but instead were rotated on the same field. Every household also had one or two cows, and six of the seven also raised more than ten domestic animals, including pigs, goats, and chickens (Shokusankyoku 1923: 6–7, 46–49).¹⁰ There were several merits to this form of farming, such as distributing risk and maintenance of soil productivity, as multiple farming was suitable for crop rotation. Efficient deployment of the labor force was also a positive, as the amount of labor necessary in each season was dispersed (Suenaga 1913: 32, 1914: 34–35). So it was natural for farmers to reduce the workforce and capital intended for growing sugarcane and instead to allot parts of these to growing other crops and domestic animals.

Second, crop rotation and intercropping as managed by farmers were problematic when it came to the particular technologies extended by the sugar companies. It was necessary to avoid repeated cultivation of sugarcane in the same field in Taiwan, as this deteriorated soil productivity, and farmers also needed to grow subsistence crops such

⁹ The average sugarcane field by household in 1920 ought to be higher than that in the early 1910s, but I have been unable to locate the data for that period.

¹⁰ These sample households were wealthier than the average in Kagi Prefecture.

as potatoes (Kaneko 1912: 473–74; Ohara 1915: 89–90). However, the method of crop rotation with which Taiwanese farmers were familiar did not sit well with certain aspects of extension work. One example of such a conflict concerned the growing of legumes before planting sugarcane. As legumes fix nitrogen and help to preserve soil fertility, agricultural engineers at the time thought that it was desirable to cultivate legumes as a green manure before planting sugarcane, to increase yields (Kaneko 1912: 473–74). But it was difficult for many farmers to do this, as they also needed to grow potatoes from winter to spring. Potatoes were a subsistence crop, important to the farmers' daily diet, so they could not compromise or easily increase the area allotted to growing legumes (Suenaga 1915: 57). Moreover, growing potatoes before sugarcane raised another problem: spacing between rows. Farmers often planted sugarcane in the furrows of the potato field while the potatoes were still growing, as it was favorable to plant sugarcane before April to improve the final harvest, though the harvest season for potatoes in Kagi was from April to March (Sugai 1911: 73; Kaneko 1912: 521–22; Kagichō Nōkai 1913: 208–9). The problem was that the space between the rows in a potato field was usually about 36 inches, but according to Suenaga, the optimal spacing to grow sugarcane was 54–60 inches. If narrower, not only was tilling of the sugarcane impeded, but it also became difficult to plow using an ox after harvesting the potatoes (Suenaga 1915: 48–49). Even if farmers grew legumes before cultivating sugarcane or between the rows of sugarcane as intercropping, there still remained problems. Because beans were another subsistence crop that could also be sold at market and whose stalks could be used to feed domestic animals or as cooking fuel (Nanbu 1914: 308; Bai 1915: 194–95), farmers did not often plow them back in as a green manure—this was a practice in no more than 23 percent of sugarcane fields (Ohara 1915: 98–99). In fact, intercropping of legumes sometimes even disturbed the growing of sugarcane, as Sasaki Kanzaburō, the manager of Ensuikō Sugar, noted:

It is true that intercropping and then plowing beans and sesban [*densei* 田菁, a kind of legume] in furrows as green manure is a good method. But when they grow higher than the sugarcane and block sunlight they severely impede the tilling of sugarcane. This is what I often witness. Especially when plowing them after fruition, the period for growing them is so long that the tilling of sugarcane becomes much worse. (Sasaki 1913: 124)

The rotation and cultivation of other crops, like potatoes and legumes, were so important for the economy of Taiwanese farmers that the extension of technologies such as the plowing back of legumes as green manure often ended in failure.

Third, some aspects of the technologies extended by companies were inconsistent with the circular economy of each household. The use of the dead leaves of the sugarcane plant is a perfect example. For sugar companies, in terms of preserving soil fertility it was preferable to plow leaves under or burn them in the field (Kaneko 1912: 600–602). However, this was unacceptable to farmers, as the dead leaves were an important fuel source.¹¹ The need for such fuel was sometimes more urgent than growing sugarcane, so even the green leaves growing on the standing cane might be

¹¹ Wood was then unavailable to ordinary people living on Taiwan's coastal plains, owing to the wholesale deforestation of the Qing era (Tseng 2006).

picked, despite the damage this did to the crop (Sugai 1911: 174–75; Miyamoto 1915: 172; Suenaga 1915: 55–56). We can also observe similar conflicts in the case of cultivating legumes. As discussed above, farmers often used stalks for feeding domestic animals and for cooking, though sugar companies encouraged them to plow these back in. And when it comes to the circular economy, too, we should not disregard the use of manure. Taiwanese farmers in Kagi in the 1910s were comfortable with using manure in sugarcane cultivation, often as a basal fertilizer or at the onset of cultivation (Oda 1915: 141; Suenaga 1915: 18–29). However, though sugar companies similarly found manure beneficial, they preferred farmers to also use commercial fertilizer at the beginning of the growing season (Kaneko 1912: 371–73; Suenaga 1915: 54). The conflict between the use of manure and commercial fertilizer can be seen in the case of those sugarcane farmers who were awarded by the companies for outstanding production, which Suenaga analyzed in detail (Suenaga 1915: 20–29). Manures were used at the start of cultivation in every case, and commercial fertilizer was mostly used only as an additional fertilizer. It was undeniable that the popular use of manure became an obstacle to the extension of artificial fertilizer, which was the companies' preferred choice.

No sooner did sugar companies expand their extension work surrounding the technological improvement of sugarcane cultivation than they encountered difficulties from harsh economic conditions, insufficient and reduced incentives, and conflict with the production systems managed by the farmers. Just as Hughes (1983) discovered when looking into the promotion of electric power in the United States, and as Moon (2007) found in the case of the extension of new varieties of rice in Java, the new technologies for sugarcane cultivation introduced by Japanese colonizers in Taiwan could not be successfully extended to farmers without tailoring them to the socioeconomic and environmental conditions. It became necessary, then, for companies to redesign the extension work so as to guide farmers to introduce new cultivation technologies.

3 Embedding Technologies

3.1 Directing Power into the Local Community

Given that their extension work did not enjoy favorable results, from the mid-1910s sugar companies began to make their efforts more sophisticated. This section, using the case of the Ensui-kō Sugar Company, examines in detail how these companies extended technologies to farmers whom they could not otherwise reach and how they avoided conflict with the farmers' production systems. By focusing on Ensui-kō, we can posit how extension work was tailored.

Ensui-kō Sugar was one of the largest sugar companies on the island, and in the mid-1910s it led other companies in the sophistication of its extension work. It was established in the southern part of Taiwan in 1903 by Taiwanese landlords but was soon bought up by Japanese entrepreneurs (Ensui-kō Seitō Kabushikigaisha 1923: 12). In the same way as other sugar companies, it developed with the institutional support of the governor-general's office and exclusively purchased sugarcane produced in its allotted territories. In 1914, its stated capital was 7.5 million yen (fourth largest of the seventeen companies on the island), and the productive capacity of its factories was 3,450 tons (third largest) (Shokusankyoku Tōmuka 1916: 11). It had three main sugar factories:

the Gannai (岸内, pronounced “annei” in Chinese) and Shin’ei (新营, pronounced “xinying” in Chinese) factories in Kagi Prefecture, and the Hatao (旗尾, pronounced “qiwei” in Chinese) factory in Akō Prefecture (阿緱, pronounced “agou” in Chinese) (*Ensuikō Seitō Kabushikigaisha* 1923: 1–6, 9–16).¹² We might estimate that more than one thousand people worked in Ensuikō’s factories and fields in the 1910s (*Ensuikō Seitō Kabushikigaisha* 1923: 114–15). The company-owned land was also larger than that of most of the other companies in terms of the productive capacity of its factories, particularly the Hatao plant (*Shokusankyoku Tōmuka* 1916: 48), which meant it was easier for Ensuikō to solve the problem of securing the necessary amount of sugarcane, an important premise for the technological improvement of cultivation. Of course, the fact that Ensuikō’s capital was greater than other companies’ (*Shokusankyoku Tōmuka* 1916: 11) was also significant, as it could therefore afford to invest more capital in extension work.

Most of Ensuikō’s sugarcane was produced by Taiwanese farmers, just as with other sugar companies in Taiwan. Table 4 indicates the variation in sugarcane cultivation in the territories of each Ensuikō factory in the 1910s. These variations were complicated by different factors. First, widespread storm damage caused a considerable decline in sugarcane acreage and unit yields in the first half of the 1910s. Second, the boom caused by wartime demand increased the acreage, but only temporarily, as the price of rice, a competitor crop, also increased from 1917. Similar variations can be also seen in the island-wide results. Although unit yields did not increase remarkably in this period, extension work was in fact being developed by Ensuikō Sugar, as discussed below. According to the Ensuikō company history (*Ensuikō Seitō Kabushikigaisha* 1923: 44–45), before the 1910s the farmers within its territory rotated crops insufficiently to preserve soil fertility and did not fertilize their sugarcane fields well enough. Faced with oversupply in the sugar market, in 1910 Ensuikō accelerated its extension efforts to reduce production costs by raising the unit yield and pricing their sugar more competitively, but it was no exception among sugar companies in facing difficulties in extending technologies to farmers.

It was with the organizational reform of the company in the second half of 1913 that previous extension works began to change. There had been two departments in the company, business and manufacture, but they were reconstituted as three departments after the reform: general affairs, mechanical engineering, and agriculture (*Yamaguchi* 1913: 1–3; *Fujimoto* 1914a: 2). From these reforms, we can observe that the intention of the company was to put greater emphasis than before on the improvement of cultivation technologies. The person who assumed the position of manager of the agriculture department was Sasaki Kanzaburō (佐々木幹三郎). After studying agriculture at Louisiana State University, from 1903 Sasaki had worked in the sugar industry section of the governor-general’s office that was in charge of improving sugarcane cultivation and sugar manufacturing and supervising the management of sugar companies. Sasaki joined Ensuikō in 1906 and became the manager of the company’s Hatao farm, successfully improving cultivation there (*Sasaki* 1959: 5–6). It was he who led the company’s new agricultural policy from 1913 to the end of the decade.

¹² Gannai and Shin’ei, located close to each other, worked jointly, and their territories were also connected.

Table 4 Annual Production of Sugarcane in the Territory of Ensuikō Sugar: 1910–20

Year	Shin'ei and Gannai Factories			Hatao Factory		
	(1) Sugarcane Acreage (kou)	(2) Yield (kin)	Unit Yield [(2)/(1)]	(3) Sugarcane Acreage (kou)	(4) Yield (kin)	Unit Yield [(4)/(3)]
1910	4,853	252,240,230	51,976	-	-	-
1911	7,241	344,331,510	47,553	3,460	164,518,150	47,549
1912	4,808	228,092,520	47,440	2,699	87,759,170	32,515
1913	3,959	73,838,228	18,651	1,873	48,932,170	26,125
1914	5,039	117,828,425	23,383	2,079	96,034,220	46,193
1915	5,033	243,145,446	48,310	2,343	126,049,950	53,799
1916	8,038	436,723,400	54,332	3,243	153,755,320	47,411
1917	9,762	648,773,780	66,461	2,668	226,989,958	85,079
1918	9,849	389,123,560	39,509	3,077	217,904,180	70,824
1919	6,733	314,082,920	46,648	2,341	173,670,980	74,183
1920	7,740	346,469,557	44,764	2,434	136,478,739	56,081

Sources: Shokusankyoku Tōmuka 1918: 34–35; Shokusankyoku Tokusanka 1926: 36–37.

The goal of the new extension work set by Sasaki was to direct farmers to subjectively introduce extended technologies by understanding their benefits rather than depend on subsidies, as demonstrated in how he encouraged farmers to use commercial fertilizer (Fujimoto 1914b: 22–23, 29). He cut the subsidy for encouraging the use of fertilizer from 1913 and, instead, formed a model sugarcane cultivation field for each village that used a sufficient amount of fertilizer, so that the benefit was immediately apparent. He explained the reason that in 1914 Ensuikō did not subsidize its farmers' buying of fertilizer: "Contrary to our aim, it is difficult for farmers to understand the true value of fertilizer as long as we subsidize it. Because we subsidize, they choose to cultivate sugarcane [using fertilizer] just for the subsidy, and do not choose to farm independently" (quoted in Fujimoto 1914b: 29–30). In fact, Sasaki's goal could be said to be one of the common ideals for Taiwan's sugar companies in their attempts to extend technologies to the farmers: they increased the subsidy for extending technologies to farmers from the early 1910s (as shown in the variations in the material charges in table 2), although they also needed to decrease the production cost.

The first policy carried out by Sasaki to fulfill his aim was reconstituting the hierarchy through which company policy was conveyed, as one of the problems of the extension work thus far had been those shortcomings that reduced incentives. It was through reorganizing the hierarchy that the company could encourage farmers more closely and more substantially and direct more power into the local community. In 1913, the exclusive territory of each factory was divided into several districts; each district contained about 2,000 kou of farmland or 300 kou of sugarcane fields, and one resident company employee (*chūzaiin* 駐在員). The territory under the Shin'ei factory, for example, was divided into eight districts, each of whose resident employees were responsible for the sugarcane cultivation there. Each district within the territories of the Gannai and Shin'ei factories usually contained seven to eight villages (*shō* 庄), while there were three or four villages in the districts within the territory of the Hatao factory

(*Ensuikō Seitō Kabushikigaisha* 1914: 14–15, 1923: 45–46; Oda 1915: 154; *Fuhō* 1911a: 59, 1911b: 26). In addition, Sasaki edited a textbook for resident employees to give them the necessary knowledge of sugarcane cultivation in the Ensuikō Sugar territories, as their lack of sufficient knowledge was one of the reasons that farmers did not rely on them (Sasaki 1913). A cadre of “material managers” (*genryō iin* 原料委員) also supplemented these resident employees, with Ensuikō Sugar appointing one Taiwanese person from each village as its material manager. Receiving a commission from the company, those material managers cooperated with the company to direct the farmers in their village to increase the area under sugarcane cultivation in their fields and to introduce extended technologies (*Ensuikō Seitō Kabushikigaisha* 1914: 14–15; Oda 1915: 154).¹³ Material managers were usually large landowners in the area and also locally influential people; it is clear that Ensuikō Sugar built its new institutions on existing social hierarchies in Taiwanese local communities (*Ensuikō Seitō Kabushikigaisha* 1914: 14–15).¹⁴ Thanks to this partly preserved but nevertheless reorganized hierarchy, Ensuikō succeeded in gaining a foothold to direct more power into the community and toward those farmers whom they could not have persuaded to adopt extended technologies in the past.

Thanks to this hierarchy, it became possible for Ensuikō Sugar to extend technologies to farmers in the village by using collective responsibility. From 1914, each village began to be assigned a certain land area for sugarcane cultivation, and also a target unit yield, depending on the environmental conditions and results as of 1910. The purchase price in each village began to be decided by their level of achievement vis-à-vis the assignment given by the company. From 1915, Ensuikō Sugar also assigned a certain amount of fertilizer use to each village, the subsidy for which also started to be decided by the level of achievement (*Taiwan Nichinichi Shinpō* 1914; Oda 1915: 154–55). With assignments imposed and also demanded by the material manager in each village, the farmers would keep an eye on one another to see whether they contributed to the assignment or not. An assistant engineer in the AAKP praised this policy: “It is an encouragement targeted not at individuals as previously, but at the masses” (Oda 1915: 154). It became possible for the company to put this policy into effect thanks to the reconstitution of the hierarchy from the company down to each village.

In addition, this hierarchy was used not only to encourage farmers from the top down but also to convey information about farmers, fields, and other environmental conditions from the bottom up. Such a situation is typified by the case of advance payments. Sugar companies generally paid farmers in advance as a fund for sugarcane cultivation, as they often suffered a lack of cash. By paying in advance, companies expected farmers to increase the area under sugarcane cultivation and also to introduce extended technologies such as commercial fertilizer and sugarcane buds (*Shokusanryoku* 1923: 52–

¹³ At the end of 1913 there were on average 740 “farmers” (*nōgyōsha* 農業者) in each *shō* of Kagi Prefecture and 828 in each *shō* of Tainan Prefecture, where the territories of Gannai and Shin’ei factories were located. On the other hand, there were 1,049 farmers on average in Akō Prefecture, where the Hatao factory was located (*Taiwansōtoku Kanbōtōkeika* 1914: 14, 270–273).

¹⁴ Although the institution of the material manager had been implemented before the reforms in 1913, each manager had usually been responsible for more than one *shō* and often did not cooperate well with the company. According to the annual report published by Ensuikō Sugar, material managers had been “so irresponsible and lazy that their reports were very inaccurate and not helpful for the company [in] deciding policy” (*Ensuikō Seitō Kabushikigaisha* 1914: 14).

53). Conversely, often farmers chose to grow sugarcane for the sole purpose of getting the advance payment, without actually investing in improved cultivation (Ohara 1915: 100–101; Suenaga 1915: 75). Yet, thanks to the new hierarchy, Ensuikō Sugar could solve this problem, with information provided by the material manager guaranteeing whether or not an individual farmer in his village could be relied on, and also whether or not his field was even appropriate for growing sugarcane (Taiwan Nichinichi Shinpō 1914). The company nearly doubled the total amount of advance payments made from 1914 to 1915 and continued to increase them in the latter half of the 1910s (Ensuikō Seitō Kabushikigaisha 1914: 22, 1915: 29). Referring back to information provided by their material managers, Ensuikō Sugar could further coordinate the content of extension works so that farmers could easily introduce new cultivation technologies.

Ensuikō Sugar also enhanced the incentives for farmers by distributing profits gained through the boom in the sugar industry as a bonus in 1915 and 1916 (Taiwan Nichinichi Shinpō 1916). Under the system of exclusive territories, sugar companies set the purchase price of sugarcane according not to the price of sugar in the market but to the price of competitor crops such as rice, rendering it difficult for farmers to see the profits that might have been expected from the increase in the sugar price during World War I (Ka 1998: 117). However, by distributing the profits of the sugar boom as a bonus, Ensuikō Sugar attempted to build better relations with farmers and to direct them toward the type of cultivation the company preferred. Following Ensuikō's lead, other companies also introduced this system of bonuses (Taiwan Nichinichi Shinpō 1917).

3.2 Taking Account of the Farmers' Economy

Not only did Sasaki need to reform Ensuikō Sugar's institutions, but he also had to redesign the components of the extension work to win over the farmers, given that in the early 1910s the company had conflicted with the farmers' economy. This section examines the new direction of extension work by analyzing two textbooks about the method of sugarcane cultivation edited by Sasaki in the mid-1910s: *Guidance for Sugarcane Cultivation (Kanshasaibaihō Annai 甘蔗栽培法案内, hereafter Guidance)* and *A Guide to Sugarcane Cultivation (Kanshasaibai no Shiori 甘蔗栽培之契, hereafter Guide)*.¹⁵ *Guidance* was written in Japanese for educating resident employees of the company, and within its pages we can determine what types of cultivation technologies Ensuikō Sugar emphasized. *Guide*, in contrast, was written in Chinese and was a translation of a speech in Japanese addressed by Sasaki to the farmers, so it speaks vividly of the interface between extension work and farmers. Comparing these two books indicates what was said, and what was avoided, at the very site of extending technologies.

Certainly, Ensuikō Sugar continued to extend technologies in as highly arrogant a manner as before, regarding its work to be a way to civilize the Taiwanese whenever the extension workers encountered trouble. We can, unsurprisingly, find such an attitude in Sasaki's *Guide*: Sasaki criticized the "lack of good faith" in farmers who diverted the company's subsidized soybean-meal fertilizer to feed their domestic animals (Sasaki

¹⁵ *Guidance* is currently located at the National Diet Library, Japan. *Guide* is to be found at the Hokkaido University Library and the National Taiwan University Library.

1915: 42); he also denounced farmers who did not till between the rows of cane or who cut down on fertilizer use for fear of risking greater losses to storms as showing the “height of stupidity” (34, 44). As the use of fertilizer was at the core of improving unit yields, and as its effect was all the more if farmers took care in tending their fields, Sasaki could not stop himself from scolding farmers in his speech to them. It is clear from Sasaki’s own exposition that Taiwanese farmers were still often treated in an arrogant manner in the extension work of Ensuikō Sugar.

However, we must not overlook a more sensitive attitude toward the farmers that is also found in these same texts and that takes their economy into account. This attitude can typically be observed at the end of Sasaki’s *Guide*, as the following excerpt suggests:

What I have described is not always consistent with your opinion as you already have a lot of experience. . . . But I also have worked in sugarcane cultivation on this island for more than ten years. I explained to you today, according to my experience. I don’t mean that there is no problem in my explanation. I just hope to study with you again and again, and also only hope to increase the benefits to sugarcane farmers. (1915: 66–67)

So we can also see that there was room for compromise, with Ensuikō Sugar admitting that its instructions were not perfect and not always appropriate for farmers.

Such a sensitive attitude toward farmers was not only verbal but could actually be seen in practice. The extension practice of plowing legumes back into the soil is a perfect example of this. As mentioned, the strategy of directing farmers to plow legumes back in as green manure before they set seed had been unsuccessful simply because pulses were an important daily food for farmers, while the stalks were used as fuel and for feeding animals. Learning from this experience, Ensuikō Sugar compromised to some extent. For farmers who cultivated legumes before planting sugarcane, Sasaki permitted them to harvest the pulses and directed them to plow back the stalks and roots (1913: 123–24). But he nearly gave up on encouraging farmers to burn sugarcane leaves in the field: “In short, though dead leaves should be burned in the field, we cannot encourage them insistently, as it is closely related to the farm economy. The way of extension work seems necessary to depend on the situation of farmers” (137). Understanding that dead leaves were often used by farmers as fuel, he decided to concede defeat on that point. It was certain that these compromised ways differed from what was recommended in texts on sugarcane cultivation in Taiwan at the period, but Sasaki did not seem to mind. It is highly probable that such compromises were conceived by Sasaki to make the extension work on the whole successful. Moreover, as Sasaki also considered extension work a means to increase the benefits to farmers, as mentioned above (Sasaki 1915: 67), he was not likely to suppose that such compromises were a crucial deviation from what the agronomical textbooks required.

Even the extension of fertilizer use was to some extent compromised in terms of the circular economy, given that farmers used as basal fertilizer manure made of feces, urine, and organic waste. Although Sasaki thought that it was usually desirable to use ammonium sulfate or Chilean nitrate as basal fertilizer to increase the unit yield of sugarcane, he compromised over this issue to avoid conflict caused by disrupting the circular economy; he only recommended that farmers use commercial fertilizer as an additional fertilizer (Sasaki 1913: 93).

Sasaki took care of the deployment of the labor force in each household when promoting earlier planting and harrowing. Earlier planting was explained as desirable because it could cut the labor force needed for weeding, as sugarcane grew large enough to prevent weed growth in the rainy season (Sasaki 1913: 81–82, 1915: 32). As to the preparation of the field, Sasaki recommended an alternative method, although he deemed the Reynoso system to be the best. This system, designed by the Cuban scientist Don Alvaro Reynoso and introduced widely in Java from the late nineteenth century, was characterized by using a large labor force to dig deep trenches and to pile up the soils in between those trenches before planting in order to enhance deeper rooting of sugarcane, irrigation, and drainage (Bosma and Knight 2004: 12; Bosma 2013: 153). But it was clear that the Reynoso system could be adopted only where a large population and a cheap labor force were available, such as in Java. Compared to Java, the population density in the Taiwanese plains was low, so cheap labor was in short supply (Tōgō 1913: 63). Sasaki had to admit that “it is very difficult to adopt the system in Taiwan due to the lack of labor power.” As a result, he noted, “we have no choice but to direct farmers to level the field by customary methods in Taiwan,” and he recommended repeated use of the traditional hoe to level the ground (1913: 70). In addition, the use of leaves as fuel was permitted by Sasaki not only because it was related to the circular economy of each household but also because farmers picked leaves in the off-season so that labor power could be used efficiently (1915: 58). Just as Dutch agricultural experts in Java in the 1910s found that improving rice productivity required not only the extension of high-yielding new varieties but also many local solutions tailored to a given area’s specific conditions (Moon 2007: 61), Sasaki also fine-tuned the contents of extension work and tried cleverly to embed technologies into the farmers’ economy.

Sasaki also tailored the explanations used in extension work so as to better win over the farmers, anticipating that any explanation that used the concepts and logic of agronomy in a top-down way would not sufficiently appeal to them. Such tailored explanations can be found everywhere in Sasaki’s *Guide*, written mainly for Taiwanese farmers. For example, Sasaki avoided referring to the results found in foreign countries and instead introduced results from the Sugar Experiment Station of the governor-general’s office or from other areas of the island. When introducing field leveling, his *Guide* referred to Matō in Tainan (麻豆, pronounced as “Madou” in Chinese) (Sasaki 1915: 20), unlike his *Guidance*, which referred to Hawaii and Java (Sasaki 1913: 70). Clearly, case examples from foreign countries were to be avoided, as they were thought to be too distant to be relevant to the farmers. Ensuikō Sugar also attempted to spark the farmers’ imagination through the use of familiar metaphors. For example, Sasaki started the first chapter of his *Guide* by metaphorically comparing sugarcane cultivation to childcare (Sasaki 1915: 10). He also used a metaphorical explanation to encourage tilling between the rows of cane: if sugarcane had a mouth, he said, it would complain that “farmers do not care about us, so our field is always dry due to sunshine and wind” (Sasaki 1915: 34–35). We can observe from these cases that Ensuikō Sugar chose to persuade them in this more subtle way.

Sasaki even justified increasing the use of commercial fertilizer from a moral point of view by using Chinese proverbs that were familiar among both Taiwanese and Japanese. As fertilizing was still one of the core components of the extension work, the explanation was not only lengthy but also attentive to detail:

For example, our future lives are unpredictable and we surely will die. Although we know about this very well, we still work hard without minding it. If we always lament about the time of death, we do not have to work and have no pleasure at all. In terms of uncertainty, our pleasure and the risk of rainstorms are the same. Therefore, do not fear the rainstorm and you should strive to achieve a higher unit yield. According to the proverb, “Do the utmost one can, and wait upon Heaven’s providence [*jin renshi er dai tianming* 盡人事而待天命].” We must do our best and leave the rest to providence [天命]. (Sasaki 1915: 44–45)

It is clear that Sasaki was setting to one side the high risk of storm damage by using a proverb well known to farmers. His explanation continued:

According to one maxim, “Only when a man is well clothed and fed can he begin to learn of ritual and righteousness [*yishi zu, ranhou zhi liyi* 衣食足, 然後知禮義].” This is not only true with man. . . . Plants also can know the ritual and righteousness [禮義]. With careful management and the use of large amounts of fertilizer, the leaves of sugarcane in the field will bend. It seems like [it is] bowing its head. If it grows even better, the stem of the sugarcane will curve as if it bent at the waist. This sugarcane is very grateful to the cultivator. . . . Since you Taiwanese sugarcane farmers know the ritual and righteousness, why don’t you give it sufficient clothes and food? I hope you can reflect on this. It would be wonderful if all the sugarcane in the island were grateful to the farmers. (45–46)

In this case, Sasaki was indicating that farmers who knew the ritual and righteousness [禮義] knew enough to give sufficient fertilizer to the sugarcane, implicitly criticizing farmers who limited the use of fertilizer as being boorish. The use of fertilizer was justified not only from the economic viewpoint but also from the moral point of view by using a famous proverb. It is no wonder that Sasaki compared his own speech in the extension work to “preaching” by a priest (Fujimoto 1914b: 20).

It was critical that the economy of the farmers began to be taken into account in the extension work of Ensui-kō Sugar from the mid-1910s. Certainly, such an attitude did not always play a key role in the extension work of other sugar companies, as it was demanded by only some engineers of the governor-general’s office and only partly pursued by sugar companies in the 1910s (Ohara 1915: 110). However, it was still significant, as it indicated that a technological system was beginning to incorporate the farming economy, with the technologies gradually permeating into the everyday lives of farmers in a subtle way.

3.3 Limits in the 1910s and Further Development after World War I

We should not overestimate the influence of Ensui-kō Sugar’s redesigned extension work in the 1910s. Wary attitudes toward imposed extension measures seem to have been considerably firm among Taiwanese farmers even in the latter half of 1910s, though farmers did begin to introduce technologies in this period. Several factors limited the effectiveness of extension outreach by Ensui-kō Sugar. First, although resident employees contributed to the development of extension work, the number of fields one employee had to manage was still so large that he was not always able to

closely encourage those farmers in his village. It was also not certain whether farmers were persuaded by the material manager in their own village, even though they were locally influential people within the existing social hierarchies of Taiwanese communities. Second, compared with the vast profits Ensui-kō Sugar gained through the sugar boom in the period, the bonuses provided by the company were limited: they raised the purchase price by only around 3 percent.¹⁶ Third, although Ensui-kō Sugar redesigned several components in its extension work and suggested alternative ways of farming, it was still not easy for farmers to introduce extended technologies. That was why Sasaki still had to blame farmers—in a rather arrogant manner—for not using a desirable amount of additional fertilizer and for not tilling between the rows of cane. Again, although we can find in his account a sensitive attitude toward farmers, his explanation was insufficiently tailored to the local situation. The old Chinese proverbs Sasaki used, such as “Do the utmost one can, and wait upon Heaven’s providence” and “Only when a man is well clothed and fed can he begin to learn of ritual and righteousness,” were hackneyed and not particularly suited to the lives of his audience, Taiwanese farmers. Explanation and encouragement that had taken root in the local environment and society would have worked better for winning the hearts of the majority of farmers. Sasaki did not understand the local culture sufficiently, however, and had no way to explain in more locally appropriate words.

Though the extension work done by other sugar companies in the mid-1910s needs further examination, still we can observe a situation similar to that of Ensui-kō. According to Ohara (1915: 110), other companies began to train extension workers in this period. For example, Meiji Sugar started to employ workers who had studied at agricultural college and, moreover, retrained them in the company farm for nearly one initial year. Many companies also encouraged their extension workers to study the local language to win over the farmers. It is certain that Ensui-kō Sugar was particularly positive about tailoring its extension work, but other companies also seemed to incorporate a similar idea in their work. However, there also remained limitations. For example, though other companies too had institutions similar to that of the resident employees of Ensui-kō Sugar, each still had to manage a large area, sometimes more than 1,000 kou of sugarcane (Ohara 1915: 112). It is clear that the progress of extension work by other companies in this period cannot be overestimated.

The wartime economic boom from the mid-1910s to the early 1920s provided a chance for sugar companies and farmers in Taiwan to make huge profits, and cultivation technologies were increasingly introduced. The price of sugar on the world market rose dramatically because of the fall in production in some production centers in Europe (Tōgyōkyōkai 1997: 70–71). Under such circumstances, sugar companies in Taiwan not only took advantage by selling their high-value sugar but also attempted rapidly to increase production on the island by increasing the purchase cost of sugarcane and the subsidies to farmers for introducing cultivation technologies (table 2). It was in this period that sugarcane farmers in Taiwan began to introduce technologies.

¹⁶ This is calculated as follows: the total sum of the bonus paid in 1916 by Ensui-kō Sugar was reported to be ¥69,000 (Taiwan Nichinichi Shinpō 1916). If it was distributed to the farmers according to the amount of yield they produced, the bonus would be about ¥0.1 per 1,000 kin, as the total harvest in that year was 669,855,109 kin (Shokusankyoku Tōmuka 1918: 34–35). The purchase price of that year was ¥3.3 per 1,000 kin (Oda 1915: 154); thus, the bonus only accounted for around 3 percent.

Table 5 shows the variation in the amount of unit use of cooperatively purchased fertilizer provided by sugar companies, which increased remarkably in terms of both quantity and value from the latter half of the 1910s. The wartime boom proved to be the temporary solution to the difficulty of extension work.

Yet extension work in this period could still not produce a favorable result for the sugar companies. The problem was twofold. First, although farmers began to introduce the companies' technologies, the unit yields of sugarcane cultivation stagnated, said to be due to the increase in the number of sugarcane fields in environmentally unsuitable areas during the boom (Ka 1998: 118). Second, and perhaps more serious, technological improvement in this period, including the increased use of commercial fertilizer, was realized by depending on the higher subsidies provided by sugar companies. We can see this from table 2, in which material charges after 1918 rose to more than ¥3 per picul at their height, staying at nearly ¥2 over the first half of 1920s, much higher than a decade earlier. This was obviously an undesirable situation for sugar companies, as one of the main purposes of the extension work was to decrease production costs by increasing unit yields.

The extension work by sugar companies in Taiwan developed further in the 1920s as they adopted a more holistic, or systematic, approach for controlling the production system of each household as a whole. This was seen not only in the sugar industry in Taiwan but also in other parts of the world; Hughes (1983: 368) has pointed out that managers and engineers in the electric industry in the United States and Europe in the 1920s were thinking more systematically. The new policy of sugar companies concerning crop rotation illustrated this development in Taiwan. It was unavoidable for sugarcane farmers to be influenced by the cultivation of other crops in their rotations, so sugar companies proposed a certain method of crop rotation instead, which was thought to be beneficial not only for the companies but also for the farmers. For

Table 5 Use of Cooperatively Purchased Fertilizer for Sugarcane Cultivation

Year ^a	(1) Quantity (kan) ^b	(2) Amount of Money (yen)	(3) Sugarcane Acreage (kou)	Quantity per Area [(1)/(3)]	Amount of Money per Area [(2)/(3)]
1916	9,365,824	2,407,203	101,865	92	24
1917	13,006,270	3,438,776	111,376	117	31
1918	16,952,491	6,738,627	83,103	204	81
1919	16,548,874	6,895,777	72,220	229	95
1920	14,475,177	9,421,258	79,867	181	118
1921	21,345,078	9,562,591	98,966	216	97
1922	15,578,300	6,206,262	86,327	180	72
1923	20,711,027	8,351,867	93,647	221	89
1924	34,428,291	10,387,778	98,371	350	106
1925	28,062,739	12,820,177	90,503	310	142

^a Data for years before 1916 are not available.

^b The data of the quantity and amount of money for the use of fertilizer and sugarcane acreage were recorded according to the year for sugar manufacturing in the source. I relocated them one year before when the fertilizer was provided.

Source: Shokusankyoku Tokusanka 1926: 36–39, 60; Shokusankyoku Tokusanka 1928: 38–39.

example, starting in 1922, Lin Hon-gen Sugar (林本源製糖) encouraged farmers to plant sugarcane as early as September between the rows of their rice fields (Tsuru 2014: 29). Ensuikō Sugar also began to encourage farmers to widen the furrows when they cultivated potatoes, making it easier to plant sugarcane (Kuroda 1924: 58). In fact, a similar development was also seen in the policies of the governor-general's office, which initiated its Basic Survey of Agriculture, investigating the household economy of farmers as a whole, including both production and consumption, unlike the statistics before the 1920s, which surveyed only distinct factors. There were several reasons for conducting this new survey: one was that not a few of the bureaucrats and engineers under the governor-general's office found the survey necessary for deciding new agricultural policy, given the unsuccessful experience of extension work in the 1910s. World War I also brought pressure to ensure the stability of the food supply. Understanding of the management of both production and consumption in Taiwanese households was seen as key to determining a new policy toward agriculture and provisioning of colonial Taiwan and of the Japanese Empire as a whole (Tōgō 1919). Furthermore, the Kanan irrigation project, which started in the 1920s and was one of the largest development projects undertaken by the governor-general's office, also pointed in such a direction: cultivation by farmers was controlled under the so-called three-year rotation system, in which they were obliged to organize an irrigation association in each district and to use a particular rotation of crops—sugarcane, rice, and one other—over three successive years (Shimizu 2015). This irrigation system, with compulsory planting of sugarcane, was also demanded by sugar companies from the 1910s on.

4 Discussion

Encountering difficulties in harsh economic conditions, insufficient and reduced incentives, and conflict with the production systems, Japanese sugar companies in colonial Taiwan in the mid-1910s began to reform their institutions so as to direct more power to local communities and to redesign the components of their extension work so as to win the hearts of the majority of farmers. This process of tailoring stands in clear contrast to the high-modernist approach pointed out by Scott (1998) and to the assumptions of previous studies of technology transfer and the colonial development project of the Japanese empire (Wu 2008; Lee 2009; Tsai 2009; Fujihara 2012; Shimizu 2015), and coincides with Moon's (2007) findings on technological policy in Java in the 1910s under Dutch colonization. But the process was still only half done by the 1910s, and sugar companies had to search for better ways to embed the technologies into the farming economy after World War I. A new age would dawn in the 1920s for the sugar companies, for the governor-general's office, and, of course, for Taiwanese farmers.

By looking into the extension of cultivation technologies by Japanese sugar companies in the 1910s, I hope to have revived several historiographical ideas. It was with the production system of Taiwanese farmers, characterized as it was by multiple farming, crop rotation, and a circular economy, that extension work by those companies seriously conflicted. Because the introduction of those technologies implied a thorough transformation of the production system and threatened the daily lives of each household, farmers often assumed a dubious attitude toward extension work in the 1910s. It became necessary for companies to resolve those conflicts in order to extend

technologies to farmers. Although the production system in colonial Taiwan has, because of technological determinism, rarely been discussed in previous studies, it clearly played a critical role in the process of agricultural technological development. In addition, the struggle by sugar companies to extend technologies in the period indicates the significance of the 1910s to Taiwanese agricultural history, a point that has been ignored in previous studies because much new knowledge and technology had already been introduced from Japan during the 1900s, while the productivity of important crops such as sugarcane and rice did not improve during the 1910s as it would in the 1920s. But in fact, introduced technologies and knowledge were extended to the local level during the 1910s, and the attempts by, and experiences of, Japanese engineers laid the foundations for the substantial developments of the 1920s.

Again, the struggles involved in extension work clearly indicate that domination of the colonial sugar industry can be discussed in terms other than those mainly focusing on the seizure of land and manipulation of sugarcane prices (Tu 1975). Though the dependence on the market through the introduction of commercialized technologies was significant, as Ka Chih-ming has argued, such a relatively simplistic point of view seems to be in danger of missing the huge impact on, and threat to, the production system managed by every Taiwanese farming household. Recent modern European economic history also focuses on those household economies as the unit of analysis, on the assumption that their transformation laid the foundations of the industrial revolution (Mintz 1985; de Vries 1994, 2008). It is interesting from a comparative viewpoint that household economies also played key roles in the development of the largest industry in Taiwan.

This narrative also highlights the mutual interactions and conflicts involved in the sophistication of technological policy. By focusing on the transformation of extension work designed to appeal to Taiwanese farmers, we can avoid the technological determinism that has been prevalent in the historiographies of imperialism. Just as recent studies of European imperialism (Moon 2007; Tilley 2011) have pointed out the tailoring or locally sensitive aspects of technological policy and scientific investigation, we might also observe tailoring and redesign in the extension work of colonial Taiwan's sugar companies, where the farming economy began to be taken into account in order to embed technologies within it. This is in marked contrast to the assumptions of recent studies of technological policy in the Japanese Empire (Fujihara 2012; Shimizu 2015) and indicates the similarity of the colonial technology policies of each empire in the first half of the twentieth century, though further examination of this argument is needed. Furthermore, Hughes (1983) discusses the development of a technological system (an electric power system) transformed by responding to changes in needs and social conditions, and as a network developing in tandem with external elements, as the technology gradually became indispensable to people's lives. His analysis provides us with a way to understand the true implications of the tailoring of the extension work done by sugar companies in Taiwan. When sugar companies began to redesign the components of their extension work by taking account of the farmers' economy rather than by simply extending their own technologies in a rather arrogant manner, this was also the beginning of incorporating the farming economy into the agricultural technology system. There, the power involved in technologies gradually permeated down to everyday lives, and farmers became dependent on that technological system in the same way that our lives now cannot be without electricity.

The transformation and maintenance of the production system await more detailed analysis, as it had diverse influences on the lives of the Taiwanese in the colonial era and was also one of the most important backgrounds to their social activity. The desirable next step in understanding would be a deeper analysis of certain villages, examining which forms of transformation were accepted or refused by which social groups in which kinds of environmental conditions.

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