•专题：民国时期的农业技术改进•

编者按：

中国是历史悠久的农业古国，传统农业技术体系独具特色，曾长期处于世界领先地位。近代以来，面对传统农业衰落的危机，政界与农学界人士均意识到引进西学、改良本土技术的重要性。民国时期，新式农政机构已在中央和地方建立，本土专业人才的增加，使农业技术改进得以在一定范围内付诸实践。一方面，这使传统农业技术开始由经验形态的技艺向理论形态的技术科学发展；另一方面，受限于社会历史条件，当时的农业技术改进也在很多方面表现出局限性。农业科技现代化的实现需要一个长期过程，民国农业技术改进史或可对当今科技兴农、振兴乡村提供历史镜鉴。鉴于此，本期组织了三篇文章，分别从作物改良、防洪治河、蚕桑树艺等方面探讨了民国时期农业技术的改进及其社会影响，以飨读者。

第一篇论文"中美合作视角下的中国作物改良计划（1925–1931）"以1925至1931年间金陵大学与康奈尔大学的中美技术合作计划为切入点，揭示了选育并推广优良作物品种对提高农业产量、赈灾济民的贡献，分析了训练专业农技人员对推进中国农业现代化的意义；第二篇论文"近代中国水利工程理念的变革"以民国前期官厅水库的构想、规划为例，在分析传统防洪治河困境与近代西方水利技术传播的基础上，展现了中国水利工程理念的主动革新过程，对中国水利工程现代化的历史特殊性进行了思考；第三篇论文"改进还是停滞：民国苏南桑树育培技术实践探讨"以民国时期蚕桑经济增强的时代背景为出发点，探讨苏南各县选育推广优良桑树品种、改良桑树育培技术的实践过程，并尝试分析其改进成效和停滞原因。

中美技术合作视角下的中国作物改良计划（1925–1931）

The Plant Improvement Project Conducted by the University of Nanking and Cornell University From the Perspective of US-China Technological Cooperation (1925-1931)

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摘 要：1925年，金陵大学邀请康奈尔大学的洛夫教授来中国订立了一项五年期的作物改良合作计划。从1925年至1931年间，康大的洛夫、马雅斯、韦根斯三位作物育种学教授共计来南京六次合作实施这项作物改良计划。计划中金大与康大作物育种人员协力合作，选育了包括小麦、大麦、高粱、玉米和棉花等大量高产抗病的作物品种，推广应用，赈灾济民。同时，合作计划也训练了一批专业的作物育种和推广人员，以继续推进中国的农学事业现代化。作为近代历史上中美首次系统性的作物育种合作项目，该计划为中国农业第一次带来了先进的科研、教育、推广三结合的科技合作模式，在推动中国农业近代化历程中的成功意义和国际影响值得高度关注。

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Abstract: In 1925, Professor Harry H. Love of Cornell University was invited to the University of Nanking to lead a five-year cooperation program of crop improvement called the Plant Improvement Project (PIP). From 1925 to 1931 Professor Harry H. Love, C. H. Myers, and R. G. Wiggans came to China to implement the PIP. With the joint efforts of specialists both from Cornell University and the University of Nanking, many high-yielding crop varieties, including wheat, barley, sorghum, corn, and cotton, were bred and distributed to farmers to improve production and fight hunger. At the same time, they trained a professional group of crop breeders and extension workers to further China's modernization of agricultural technology after the PIP was ended in 1931. As the first systematic cooperative crop breeding program between China and the United States, the PIP brought a new technological cooperative model of "integration of agricultural research, education and extension" for China. The PIP's successful significance and international influence on the agricultural modernization in China demand more scholarly attention.

Key Words: University of Nanking; Cornell University; Plant improvement; US-China
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China and the United States had a century-long history of communication. Throughout the twentieth century, many Americans sought to help improve agricultural education and modernization in China. Unofficial exchanges, religious extension, and individual cooperation gradually contributed to organized and evergrowing agricultural exchanges and cooperation between China and the United States. Historians have argued about the assessment and impact of these U.S.-China agricultural programs and cooperation for decades. Among them, Shen Zhizhong in his book, *The Sino-USA Exchange and Cooperation in Agriculture from 1897 to 1949*, argues that while Chinese modern agricultural industry was born and grew up in the semi-colonial and semi-feudal society, both Chinese and American agriculturalists demonstrated their professionalism and sense of responsibility via their dedicated work in China.[1] Some scholars, however, criticize the effects and outcome of these programs, arguing they were doomed to failure. In the book of The Stubborn Earth, Randall E. Stross assesses these American agricultural assistance programs in China were "too often regarded merely as a technical challenge for the agronomist in the laboratory" because "the Americans failed to realize that changes in the wider polity, society, and economy were necessary."[2] Utilizing the archival sources from both China and the United States, my paper on the Plant Improvement Project interprets a specific example to more comprehensively and persuasively enhance our understanding of U.S.-China technological communication and interaction in the first half of the twentieth century.

I. Background of Communication

The Qing government after the first Sino-Japanese War of 1894-1895 faced many serious challenges, and therefore sought the modernization by encouraging Chinese students to go abroad for further study. After 1908, the Qing government utilized the Boxer Indemnity Scholarship offered by the U. S. government to send a group of students majoring in agricultural science to study in American universities.[3] Many of these students later became important agriculturalists during the Republic of China. From the U.S. side, J. J. Mott, a graduate of Cornell University, established the "Student Volunteers in Foreign Missionary Movement" at the end of 1888. Between 1888 to 1918, this organization sent over 8,000 missionaries abroad, and 30% of them, about 2500 missionaries, were sent to China.[4] While they were taking up missionary activities, they spread western science and technology to those they met.

Meanwhile, Chinese scholar-bureaucrats recognized the importance of western agricultural science and technology and they began to actively learn modern agricultural practices from western countries. In the earliest stages, they spread western agriculture knowledge by merely translating and introducing various books and articles. For instance, Luo Zhenyu established the Journal of Agriculture, "to detail the agricultural policies and situations of all provinces, and also translate foreign agricultural books and journals for reference."[5] Everyone in these efforts began promoting western agricultural practices, along with plant breeding in China which transformed the conventional style of farming to a more distinct modern style.

Although dating from the early twentieth century, agricultural schools and colleges were already established across the country. However, these scattered nongovernmental exchanges between China and foreign countries were not well-organized. Despite this, these agricultural exchanges laid a foundation for future large-scale, well-organized cooperation between China and the United States.

In 1911, however, a major development occurred. Joseph Bailie, a professor of English at the University of Nanking, organized the Volunteer Peasant Association for afforestation on the Purple Mountain, but he did not have adequate sources of funding for this work. In 1914, however, he helped establish the College of Agriculture and Forestry at the University of Nanking (CAFUN) and introduced a four-year undergraduate program in agriculture. The CAFUN became the first four-year agricultural college in China.[6] The CAFUN followed the examples of American agricultural colleges, especially the system of the College of Agriculture at Cornell University (CACU) Accordingly, the CAFUN established majors, courses, and its policies for teaching and administration.[7] In 1924, the University of Nanking registered with the New York State Education Bureau, which meant that a bachelor's degree from the University of Nanking was equal to that from any university in the state of New York. Compared with other Chinese universities, the University of Nanking played a leading role in the academic communication between China and the U.S.

Cornell University, established a few decades earlier than the University of Nanking, also took the leading position in agricultural science. Its College of Agriculture had enjoyed a good reputation for a long time in China. After the 1911 Revolution, many agriculturalists and officials, such as Jin Bangzheng, Zou Shuwen, Zou Bingwen, T. S. Guo, Xie Jiasheng, Ling Daoyang and Mu Ouchu, graduated from the College of Agriculture at Cornell University and returned to China. (1, p45) These pioneers in the research and teaching of agriculture and forestry not only made great contributions to the agricultural science in China, but also strengthened the influence of Cornell University in China.

Cooperation between Cornell University and the University of Nanking dated to 1914, when Professor Reisner, John, H taught agricultural courses at the University of Nanking. In 1916, when Joseph Bailie, the dean of the CAFUN, resigned to return to the United States, Reisner succeeded him. During his tenure, Reisner employed several students who had graduated from the CACU. In 1918, C. W. Woodworth from the United States took charge of setting up the Department of Sericulture in the CAFUN. Two years later, the University of Nanking invited Professor J. B. Griffing to be first the director of the Department of Cotton Improvement, and later in 1924 to be the director of the Department of Rural Education at the University of Nanking. In 1921, John L. Buck, an agricultural economist who graduated from Cornell University, held the postion of the head of the Department of Agricultural Economics in the CAFUN. In 1924, Professor R. H. Porter, an American plant pathologist, taught courses about phytopathology, and also later, established a study group for phytopathology at the CAFUN. This interaction between Cornell University and the University of Nanking facilitated future official cooperation between the two universities.

II. The Implementation of the Plant Improvement Project (PIP)

In 1919, a severe drought in northern China caused major crop failure and famine, leading to large numbers of dead and suffering from starvation. Some Americans formed the American Committee for China Famine Fund to raise money to give relief to the people in the stricken areas, but not all of the funds were allocated properly.[9] In 1922, learning that about one million dollars of the donation were left, Dean Reisner went back to America to ask the committee to allocate the money for the improvement of agriculture and forestry in China.[10] In 1925, Reisner invited Love, Harry, H to be the special professor at the University of Nanking. Soon thereafter, the University of Nanking, Cornell University, and the International Education Board established a five-year cooperation program for crop improvement, called the Plant Improvement Project (PIP) From April to September for the next five years, professors from the Department of Plant Breeding at Cornell would go to China to conduct research on crop improvement. The University of Nanking provided the research facilities, and experimental stations. The International Education Board was responsible for covering the travel expenses for the Cornell representatives.[11] To expand their crop improvement work nationwide, except at the Nanking Station as the central station, there were several cooperative stations.[12] By the summer of 1925, a number of stations joined in working under one general plan for the improvement of the crops of China. The University of Nanking took the responsibility of making technical plans and recommending technical staff. The University of Nanking also provided funding for all the cooperative stations except Yenching University's Agricultural Experiment Station and the Oberlin Shansi Memorial Schools.[13]

The PIP started in 1925 and came to an end in 1931. But during this period, the program was interrupted due to the unstable politics and wars in the nation. In 1928, it was suspended for a year then continued until 1931.[14] In these years, Love, C. H. Myers and R. G. Wiggans each went to China twice. At that time, faculty and students of CAFUN, such as T. H. Shen, S. Wang, C. M. Heh, Shen Xuenian, Dai Song'en, and Shen Shouquan, participated in this program, and most of them went to the CACU for further study. Eventually, they returned to work at the University of Nanking, other agricultural colleges or universities, or government institutions conducting agricultural research. Yields of grain crops, including wheat, barley, grain sorghums, and rice, were increased by planting the improved crop varieties, especially wheat and grain sorghum in northern China. (12, p.137)

Love came to Nanking on April 10, 1925. He reviewed the data records of current experiments and gave suggestions for recording future experiments to highlight the importance of standardizing plant breeding methods, collecting and organizing experimental data, and interpreting results.[15] This was not only at the Nanking Station. Later, Love expanded the research for increasing the yields of wheat and barley at other stations in China. On May 18, Love with Prof. G. E. Ritchey, the Head of the Department of Agronomy, left Nanking for Yixian, Shandong. They inspected the work which had been conducted by K. M. Gordon at Shantung Agricultural and Industrial School where 134 selections were made from head row tests in the autumn of 1924. Then, they both continued to Henan, where they inspected the wheat breeding and other crop experiments conducted by G. K. Middleton at the Kaifeng Baptist School. This station selected 2,000 heads of wheat for inspection, from which a selection of 208 heads were made in further rod tests. Most of these varieties continued to be tested in the PIP from 1925 to 1926.[16] Leaving Kaifeng, Love went to Nansuzhou, Anhui, to review the wheat work at that station with H. H. White. After the field investigation in Shandong, Henan, and Anhui, Love realized that the expansion of the program was restricted due to the lack of techniques and lack of funds.

Then, Love suggested reorganizing the program at all the cooperative stations and providing them with support for research. Most of these mission stations were located in central and northern China. Through proper training procedures, these missionaries could take the responsibility as professional crop breeders. On September 25 and 26 of 1925, a conference was held at Nanking between representatives of the CAFUN and the mission stations.[17] Those who attended the conference were listed as follows: Gordon K. Middleton from Kaifeng Baptist College, Kaifeng, Henan; H. H. White from Presbyterian Mission, Nansuzhou, Anhui; A. L. Carson from Presbyterian Mission, Weixian, Shandong; T. S. Guo, the Chinese Dean of College of Agriculture and Forestry at Nanking, Reisner, the American Dean of College of Agriculture and Forestry at Nanking, G. E. Ritchey, the Head of Department of Agronomy; Love, the Cornell Representative. This conference indicated clearly that it would be much more efficient if all of the interested agencies would join together in one comprehensive program of crop improvement under an experts' centralized supervision.[18] Soon six mission stations entered into the program actively. The names of these stations and the Nanking Station, together with the crops tested in each, are listed in Table 1.

Table1 Distribution of Crops in the PIP[19]

Station	Winter Crop	Major Summer Crop	Minor Summer Crop
Kaifeng	Wheat	Gaoliang	Beans(Millet)
Nansuzhou	Wheat	Beans	Gaoliang
Yixian	Wheat	Gaoliang	Beans
Weixian	Wheat	Gaoliang	Beans
Wuchang	Wheat	Gaoliang	Beans
Guide(Shangqiu)	Wheat	Cotton	Rice
Nanking	Wheat、Barley	Corn	Beans

During the PIP, the number of experimental stations kept growing. By 1931, there were four college-affiliated stations and thirteen cooperative stations providing experimental data on a regular basis. The 13 cooperative stations were listed as following: Anhwei Provincial Agricultural Experiment Station, Anqing, Anhui; Central China Teachers College, Wuchang, Hubei; College of Agriculture, Central University, Nanking, Jiangsu; Jefferson Academy, Tangshan, Hebei; Kaifeng Baptist School, Kaifeng, Henan; Kiangsu Wheat Experiment Station, Xuzhoufu, Jiangsu; Nanhsuchow Presbyterian Mission Station, Nansuzhou, Anhui; Oberlin Shansi Memorial Schools, Taigu, Shansi; Shantung Agricultural and Industrial School, Yixian, Shandong; St. Paul's Canadian Church Mission Hospital, Shangqiu, Henan; Tsangchow London Mission, Cangzhou, Hebei; Weihsien Presbyterian Mission Station, Weifang, Shandong; Yenching University Agricultural Experiment Station, Beiping.

Love recommended that crop improvement in China would proceed more satisfactorily if the interested agencies would join together in one large plan of cooperation, rather than for each individual or station to work separately. Moreover, the same plans for selection and testing the various crops would be used at each station so that the results would be comparable, and that the improvement work would be closely associated with the diseases of the crops studied.[20] Love and his colleagues at Nanking prepared a detailed memorandum for all stations to standardize the crop improvement methods. They required all the stations to follow selecting and testing methods and procedures illustrated in their two instruction brochures, "General Suggestions for Methods of Selecting and Testing," and "Methods for Rod Row Testing." This was the first time a research program used standardized methods for crop improvement in China. Meanwhile, all the stations cooperated to conduct the experiments systematically.

Myers, the second representative crop breeder from Cornell to China, arrived in Nanking on March 24, 1926, accompanied by T. H. Shen, a doctoral candidate at Cornell. In May, Myers and Shen visited most of the cooperative stations. Approximately, 8,000 head rows of wheat were grown at the Nanking Tai-ping-men Farm and several cooperative stations. In the spring of 1927, Wiggans was the third representative from Cornell University to visit China. At that time, the Nationalist army was marching from south China to central and northern China. It was guaranteed that the troops around Nanking would pass the city without any disturbance. But situations near Nanking had experienced great changes, forcing foreigners to leave the city. Therefore, Wiggans arrived in Shanghai instead of Nanking to meet with the Chinese staff responsible for the project. During his stay, Wiggans made arrangements for the program and the experimental stations regularly. Because of the chaotic political situation, Wiggans returned to Cornell after one month in Shanghai. The Nationalist's Second Northern Expedition in 1928 made it inadvisable for a Cornell professor to visit the University of Nanking that year. University officials decided that the program should come to a pause and restart in 1929. Even so, the plans for the PIP in the autumn of 1928 and in 1929 were carried forward in a highly satisfactory manner.

On April 19, 1929, Love arrived in Shanghai to start his second trip to China. He was concerned about the progress of crop breeding, however, he was informed that the experimental work had neither been interfered with at the University of Nanking nor at any of the cooperative stations despite the wars. Seeds had been divided into two lots to be stored in different places for further tests in case of wartime destruction. Love felt satisfied that the PIP was being carried forward by the Chinese scientists themselves during their one-year absence. Wiggans also returned to Nanking on March 29, 1930, for his second trip to China, and stayed until October 29. He spoke highly of Chinese colleagues in the PIP which as he noted, "The personnel in charge were so thoroughly interested in the work and impressed with its importance that no sacrifice was too great in order to prevent loss."[21] The PIP achieved such great success that in the fall of 1930, the President of Yenching University, J. L. Stuart, asked Nanking to take over the work of its Department of Agronomy. Yenching University had received 250,000 dollars from the United States to establish agricultural stations. From then on, the University of Nanking was entrusted with the establishment and reorganization of the stations.[22] In December of 1930, Shen, as the representative of the University of Nanking, went to the station at Yenching University to investigate its research conditions and to discuss a reorganization plan. Shen suggested to Stuart that livestock raising and fruit tree planting should be stopped so that all the human and material resources could be concentrated on the breeding work of wheat, kaoliang, corn, millet, and soybeans. In this way, improved varieties and methods would be distributed to farmers in five to six years. (12, p.150) Stuart approved Shen's recommendation, and an agreement was reached by both universities.

Myers reached Nanking on February 20 of 1931, and remained until October 2. He went to Yenching University on March 18 to start the improvement work proposed by Yenching University. Based on consultations with scientists at both universities and his own investigations, Myers suggested that the improvement work at Yenching University should be limited to one major crop. On May 26, 1931, his report was approved by the two universities. This agreement demonstrated that the crop improvement work at Yenching University was officially a part of the PIP. By 1931, Myers noted that conditions in CAUN had greatly improved. he tested crops included wheat, rice, soybean, barley, corn, cotton, kaoliang, and millet. The testing methods included head row tests, rod row tests, and genetic research, which proved that the PIP was progressing rapidly in all respects.

Professors from Cornell University provided much technical assistance to the program, formulating the development plans for Chinese agricultural research, guiding the crop breeding work, and helping to foster agricultural talents by broadcasting the theories of crop breeding through lectures and book publications. In this way, Chinese staff and students gained a systematic understanding of breeding.[23]

Love was the first representative from Cornell who participated in the PIP. He attached more importance to the implementation of breeding in a scientific way. He asserted that, "as for the major crops in China, the quantities and qualities of these crops would be greatly increased if scientific breeding methods were used for their improvement."[24] Love made a practical plan to ensure that the improvement of crop breeding continued to function after the program ended. Their emphasis on standardizing crop breeding methods was a breakthrough for Chinese agricultural science and technology.

R. G. Wiggans also emphasized the significance of scientific systems for crop breeding. In his lectures, he addressed many times that crop taxonomy was of great importance in the PIP. China had a long history of crop cultivation. Crops were widely grown in different regions while no one classified crop varieties. Therefore, same as in some western countries, historically speaking, there was also no tradition to sort crop varieties in China. It was particularly important to carry on research on classifications of crop varieties, and then put the research findings into practice.[25] Wiggans and his colleagues created a course about crop taxonomy, which provided the comprehensive theories for program development.

As the last representative from Cornell University, C. H. Myers played a key role in the project. To ensure that the crop improvement would be continued and expanded by Chinese staff after the program ended. Myers recommended the creation of a standing project committee of the College of Agriculture with the dean as an ex-officio member. It would serve as a non-administrative institution of the college taking the responsibility of all the crop improvement related work in different departments. This committee could break the barriers between administrative institutions to lead crop breeding work systemically and comprehensively.

Not only did the three professors make great contributions to the project, but a large number of well-trained Chinese and American faculty and staff at Nanking, such as Ritchey, Shen, Zhang Zhiwen, S. Wang, T. S. Kuo, C. M. Heh, R. H. Porter, and Qian Tianhe, played a vital role. It is worth mentioning that Shen, after receiving a master's degree at the University of Georgia, entered Cornell University in 1924 for a doctoral degree in Plant Breeding and Genetics. When Shen graduated from Cornell in 1927, he went to work in the CAFUN to continue this project. His most remarkable achievement was the improved variety of wheat, Nanking No.2905. The work from selection to distribution with Nanking No.2905 took 8 years between 1925 and 1933. (12, p.140) Shen also spent 8 years on head selections and field tests at Nanking Station outside the Tai-ping-men of Nanking, and he compared Nanking No.2905 with 537 foreign varieties at Nanking Station and Nansuzhou Station. Finally, in the summer of 1934, it was decided that Nanking No.2905 was the superior variety of wheat and the first promising variety found with the pure line breeding method established by the PIP.

Shen was a typical representative of Chinese crop breeders. Faculty and students from the University of Nanking and co-workers at all cooperative stations were certainly the mainstay of the program. In the *Final Report* by C. H. Myers, he evaluated the Chinese staff saying that, "This report would be incomplete without especial mention of the services of Mr. T. H. Shen. His knowledge of China and his acquaintanceship with educational leaders everywhere made possible many contacts that would otherwise not have been made." (17, p.13)

During the PIP, promising varieties of crops, such as wheat, beans, rice, gaoliang, millet, and barley, were cultivated and then distributed among farmers. According to the *Statement of Project* made by Reisner in 1931, until then, 28 improved strains and varieties of wheat, millet, gaoliang, corn, and cotton had been put into more fields and had already been distributed.[26] This project made great achievements in terms of the improvement of seed varieties and the increase of food supply at a time when people suffered from serious food shortage. Planting improved varieties seemed to be a shortcut of solving the grain problem in China.[27] Besides, the standard methods of crop improvement were formulated in China for the first time, and then extended to the whole country. Meanwhile, the program cultivated a group of well-trained agricultural scientists and technicians with professional knowledge and creativity, who were able to carry on and expand the work after the Cornell professors had left.

1. Wheat

Before the PIP, in 1914, agricultural scientists at the University of Nanking developed the first

Chinese wheat variety "Nanking No.26," which was an important attempt to develop modern crop varieties. Then, in 1925, workers from the University of Nanking, under the guidance of Love, made thousands of selections in wheat through 20,222 head and rod rows tests with 465 varieties of foreign wheat included in the test. This was one of the largest wheat experimental planting work undertaken anywhere worldwide at that time. Eight superior varieties were selected in the region of Nanking. During the period from 1927 to 1931, yield tests had been done on these varieties.

Full responsibility for the wheat research at Nanking resided with Shen, after he graduated from Cornell University in 1927. Under his direction, the wheat project made substantial progress at Nanking and at the cooperative stations. Nanking No.2905 was one of the most successful improved varieties in the PIP. In 1934, the Extension Department was set up in the CAUN for expanding the new variety of wheat, Nanking No.2905. Yields of Nanking No.2905 wheat compared with Nanking No.26 are listed in Table 2. When the comparisons were made, the average yield of Nanking No.2905 over a five-year period was 30 bushels per acre. The gain over the Nanking No.26 averaged 6 bushels per acre, or about 25 percent. Numerous tests showed that Nanking No.26 yielded about 7 percent more than the traditional varieties, therefore Nanking No.26 wheat would yield about 32 percent more than the farmers' varieties if grown under similar conditions. Nanking No.2905 was also the variety of wheat grown with the largest acreage in China because of the resistance to lodging, early maturity, and the resistance to rust at that time. After ten years of testing from 1925 to 1934, Nanking No.2905 was extended in Nanking for four more years until 1938, and then this variety was extended in Sichuan for six more years until 1943. Its total acreage of extension amounted to roughly 1.3 million acres, which indicated that Nanking No.2905 had the most acreage of extension among all the improved varieties.[28] After the Sino-Japanese War, Nanking No.2905 was planted in Jiangsu, Anhui, Sichuan, Shansi, Hubei, and other provinces.[29]

Table 2 The Comparison of Nanking No.2905 Wheat with Nanking No.26 (Bushels per Acre)(10, p.29)

Year	Actual yield+	Gain over No.26
1927	42.8	19.8
1928	29.4	8.8
1929	53.3	26.9
1930	40.8	9.7
1931	23.4	-5
1932	28.1	7.7
1933	28.3	4.3
Average	30	6.0=25.0%

2. Soybean

R. G. Wiggans believed that it was important to conduct an adequate soybean program, since soybean was one of the main food crops in China. Before the PIP, soybean improvement work had never been significantly studied in China. Shou Wang of the Department of Agronomy at Nanking also gave special attention to soybean work. Wang made detailed plans of certain crosses which helped not only determine the mode of inheritance of some characters but also the obtaining of certain new combinations of economic importance.[30] From 1924 to 1930, a large number of soybean selections were made at all the cooperative stations (see Table 3)

Table 3 Soybean Selections at Cooperative Stations (17, p.43)

Year	No. of selections	Province
1924	407	Jiangsu
1925	600	Henan
1925	1080	Jiangsu
1925	100	Anhui
1925	909	Shandong
1925	61	Shandong
1925	52	Nanking
1929	500	Jiangsu
1930	2500	Jiangsu
Total	6209	

As the program proceeded, the improvement work on soybeans at Nanjing achieved important progress. At the Nanking Station, Wang made comparative tests on those selections from their experimental fields and local farms, among which was one named Nanksoy No.332. Nanksoy No.332 had an outstanding performance. The results from a five-year test are given in Table 4. During a five-year period, the average gain over the standard variety was 5.46 bushels per acre. Subtracting this figure from the average yield of Nanksoy No.332, 17.68 bushels per acre, the average yield of the standard variety was 12.22 bushels per acre. Regarding this figure as a baseline, Nanksoy No.332 had an average gain of 44.68 percent. Therefore, the value of soybean's improvement was self-evident. This new variety of soybean with high yield and good quality was distributed to farmers for planting in the surrounding area of Nanjing.

Table 4 Yield of Nanksoy No.332 Compared with the Check Variety(10, p. 38) (Bushels per Acre)

Year	Actual Yield of Nanksoy No.332	Gain Over Check
1926	20.3	9.6
1927	24.3	6.7
1928	15.4	4.1
1930	13.8	5
1931	14.6	1.9
Average	17.68	5.46/44.68%

Since 1932, Nanksoy No.332 became the standard variety in comparative tests of soybeans in China, which was also called Nanking Soybean in other countries. Undoubtedly, Wang's research played a vital role in improving yields of soybeans.[31] In 1939, Wang continued his research at Chengdu. Wang and Yuhua Ma conducted a series of further studies on soybean. They cultivated four new strains of pure lines at Chengdu, some of which had higher yields and protein contents than Nanksoy No.332. They also developed a new variety of soybean, Nanhsuchow No.647, at the Nanhsuchow Station.[32]

3. Rice

Not many superior varieties of rice in China were cultivated by scientists at the CAFUN. But the PIP team was responsible for a large rice breeding research program based on variety observations, head row tests, rod row tests, two-rod tests, five-rod tests, and ten-rod tests[33] The breeding method of head-row and pure lines put forward by Love, Harry, H achieved success at all cooperative stations when applied for the first time, and then it was widely extended. The specific breeding process was described as follows: individual selection (1st year)-single-row test (2nd year)--double-row test (3rd year)--five-row test (4st year)--ten-row test (5th year)--advanced test (6th year)--multiplication and extension (7th year)[34] Rice improvement work was developing both at the Nanking Station and the Wuchang Cooperative Station. In 1924, the University of Nanking started the breeding work of rice but with only comparative tests of different varieties. Later, a new strain, Nanking No.1386, was cultivated with the method of pure-line selection. Since 1927, the experimental work at Nanking had been under the direction of Shen. Because the experimental land of the University did not include a large area suitable to grow rice, the work with rice had been limited. However, some new varieties gave yield increases ranging from 14.6 percent to 29.6 percent over a good farmers' traditional variety. The improved rice varieties included Nanking No.909, Nanking No.946, and Nanking No.1386, with the latter variety averaging yields of about 300 catties per mu.①

4. Gaoliang

Gaoliang, a grain sorghum, was an important crop adapted to the drought conditions of north central and northwestern China. Before the PIP, no breeding work with gaoliang had been ever attempted in China. In 1925, extensive selections were made at Yixian, Kaifeng, Nansuzhou, and Weixian, all these northern cooperative stations, totaling 1248 individuals. Nanking was located beyond the area where gaoliang was usually grown, therefore the purpose of the work with gaoliang at Nanking was rather for study of varieties and types than for securing yielding data.[35]

To obtain promising varieties of gaoliang, selecting experiments began at stations in central and northern China. Stations at Nansuzhou, Kaifeng, Yixian, Yenching, and Taigu conducted most of the selections with gaoliang. Wiggans and Heh then went to Suiyuan, Jinan, and Baoding to study the specialties and characteristics of gaoliang. During the selections

① Data from *The Cornell-Nanking Story*. Catty is a Chinese measure equal to 500 grams. Mu is a Chinese measure equal to 0.0667 hectares or 0.11 acres.

of gaoliang, Wiggans emphasized the importance of the accuracy in the comparative tests. The areas for testing must be different in terms of climate and soil. The soil in experimental fields must be typically representative of the regions, including both dry land and irrigated land, with scientific methods used in the tests.[36] According to the statistics, six new varieties of gaoliang were selected at Nansuzhou Station. At the Kaifeng Station, four varieties had been obtained with average yields 20 percent higher than the farmers' traditional variety. Very promising varieties had also been obtained at Yixian. In a four-year test, these selections ranged from 28 to 48 percent more than farmers' varieties grown in the same tests. The two leading selections had 47 to 48 percent increases.[37]

After the PIP ended, breeders at Nanking continued to place these new varieties into regional tests at stations of Kaifeng, Yenching, Nansuzhou, and Yixian. After a seven-year test, Yenching No.129 was obtained, which yielded 5 times more than the average of local varieties. Then Yenching No.129 started to be distributed at the beginning of the 1940s. Other new varieties included Nanhsuchow No.33184, Kaifeng No.2612, Ding County No.33, and Nanhsuchow No.2642.[38]

5. Barley

Although barley was not top on the list for improvement, the PIP still made some progress in this aspect. From 1925 to 1928, American varieties from Texas and Wisconsin were introduced into the tests by S. Wang. After the harvest of 1930, Wang found that these American varieties of winter barley were slightly better in yield than the average domestic ones. However, they were too late in maturity to adapt to the cropping system practiced in the Yangtze Valley. Thus, in the summer of 1931, large-scale selections were made from 10,000 strains of hull-less barley and 1027 strains of hull barley by Wang for the fall planting.[39] Then in 1932, after the ending of the PIP, Wang went to the Department of Breeding at Cornell University for further study on barley selection. At Cornell, he developed a new variety with a strong resistance to mildew and rust. This variety was named after Wang as "Wong Barley."[40] In the tests for yield comparison of four varieties of winter barley conducted by the CACU at Ithaca from 1939 to 1942, the average yield of Wong was 50 bushels per acre, which was higher than the varieties of Kentucky No.1, Michigan Winter, and Poland.[41] The CACU prompted this variety widely in New York state via admiring that, "those farmers who want to grow winter barley may find that Wong is the most desirable sort."

This successful research on barley proved that while China benefited from the PIP with agricultural expertise from Cornell, American agriculturalists also practiced their theories and methods. As Love once admired in the radio that, "we in New York State should be very thankful to this Chinese plant breeder who, while developing better varieties for China, has produced something that is so promising for New York agriculture."[42] Those new varieties of crop and improved research methods gained from their experiences in China benefitted American farmers as the PIP findings were implemented in the U.S. The PIP was not just a one-sided technology output with unilateral benefits.

6. Corn

In 1930, Wiggans led breeding work with corn at the stations of Nanking and Yenching, utilizing the new corn breeding method developed in the U.S. The new method focusing more on the inbreeding, single crosses, and double crosses. Wiggans placed more emphasis on the breeding of all open-pollinated crops . Wiggans inbred 868 individual ears of corn collected from many locations in China and from many strains introduced from the U.S. to compare their yields. The results of that year, however, were surprising. Only two of the introduced American varieties yielded as much or more than Nanking Yellow, a local standard variety, while the inbred varieties from native pure line ones out-yielded Nanking Yellow. There were limitations that can be expected by the introduction of high-yielding varieties of an open-fertilized crop into an entirely new and different environment.[43] The work done under the direction of Wiggans in 1930 revealed that better varieties of corn might be among the native inbred lines, because none of the introduced varieties proved superior to the local varieties. This is also the lesson the PIP taught us. It is a common belief that some superior varieties when placed in other regions will have the same high performance in new local conditions. However, the truth is that different organisms cannot be so easily grafted into new geographic regions without considering needed adjustments.

In 1928, the University of Nanking and Yenching University cooperated to carry on breeding work with corn, and, in 1933, two double-cross varieties were developed. In the cooperation between the University of Nanking and Oberlin Shanxi Memorial School, the famous Oberlin Golden Queen was selected among American corn varieties. (31, pp.29-30) Because the improvement work with corn in China achieved great success in northern China due to proper climate, the improved varieties were accepted by farmers quickly.

7. Cotton

Before the PIP, with the financial support from foreign cotton mills and Cotton Anti-adulteration Association in Shanghai, a Cotton Department was already established at Nanking in 1920. The head of the department, John B. Griffing, began improvement work with cotton in the same year.[44] They made over 50,000 selections, among which one proved superior to others for yielding ability and quality of lint. Known as “Million Dollar”, it was accepted by many farmers that new variety seeds were distributed along the coast from Shanghai down south to Ningbo, as well as from the coast to the interior. In 1926, A. J. Bowen, the president of the University of Nanking at that time, firmly believed that there was more continuous work to be done on crop improvement because, “If Million Dollar and the others isn’t degenerating, there is a Two Million Dollar variety to be yet found.”[45] However, due to bad business in the cotton mill industry, the financial support for the Cotton Department was cut off in 1923. Their department became self-supporting which meant it was too heavy a burden for Griffing to do both breeding and extension work of cotton on his own without help. Griffing had to leave Nanking and head back to the States in 1927.

In 1926, Reisner wrote to Griffing proposing that since the program was able to accumulate a reserve of a few thousand dollars for the cotton work, it would be more efficient to have the cotton improvement work brought into the Department of Agronomy as a part of the PIP.[46] After that, cotton breeding work was included as a part of the PIP. Under a unified administration, there was no need for cotton breeding work to compete with other crop breeding work for labor and land. The PIP conducted tests on both domestic cotton and American cotton varieties in northern China. The results showed that some varieties from the U.S. had good performance. Trice Cotton, for example, grew well while Stoneville # 4 came to be a more popular variety in the area around Peking and Hebei. After years of improvement work and tests in the PIP, results indicated that the Trice Cotton was suitable for growing in the Yellow River Basin. While the Yangtze River Basin, especially Nanjing and surrounding areas, was perfectly suited for the cultivation of the Acala Cotton. Million Dollar was generally accepted around the coastal area in Jiangsu and Zhejiang Provinces. The prices of these three variety cottons were five or six yuan higher than average ones, which proved their high quality and wide acceptance.[47]

To develop more new varieties, the PIP breeders also collected additional varieties for further breeding purposes, consisting of 27 American varieties obtained from Arkansas, Georgia, and Oklahoma, and 32 varieties of Chinese cotton from the provinces of Hebei, Shandong, Jiangsu, Anhui, Jiangxi, Zhejiang, Hunan, and Hubei. They also made a large number of individual selections from their own stock in an effort to obtain superior strains. However, cotton improvement was also very unique compared with other crops’ improvement because one wanted not only yield but also length of lint that would meet the conditions and requirements of the manufacturer.[48]A summary of the work showed that in the 300 mu of land planted cotton, 2834 individual selections were tested. In the cotton tests, two major indicators were staple length and lint index. (17, p.50) Later, selections of pure lines were made from varieties introduced from the U.S. Consequently, two strains of U. N. Acala 481 and U. N. Acala 149 were cultivated. Along with the U. N. Trice, these new varieties were then distributed along the Yangtze River Basin and the Yellow River Basin respectively.[49] By 1931, the cotton improvement work was a major research focus of the PIP. The breeding work of cotton at the University of Nanking played a vital role in the modern cotton research of China, which made great contributions to cotton's yield increase and agricultural development.[50]

8. Seed Multiplication and Distribution

As Reisner pointed out before, China was not only in a great need of knowledge for solving her agricultural difficulties, but also in urgent need of developing extension work to have this knowledge applied by the people to their agricultural practices.[51] Therefore, farmers might obtain higher yields from their land without changing appreciably their cultural methods. In 1924, the Extension Department was set up in the CAFUN to focus on the training of workers conducting distribution work. According to the records, from December 1,1927 to December 1,1928, around 277.93 piculs of improved seeds of wheat, corn, and cotton were distributed by the Department of Agronomy along.[52] With the guidance and institutional support from the agricultural extension at the CAFUN, the seed distribution program continued to expand even during the war years. As is shown in Table 5, during the period from 1923 to 1930, a large amount of seeds of cotton, wheat, and corn were distributed to farmers through the Department and all the cooperative stations.

Most seeds were sold at a flat price, just a little higher than the market price, to regions where the seeds were actually used for planting. Therefore, many farmers benefited from improved seeds, which stimulated them to publicize more for the PIP. Excluding the influence of natural disasters and wars, seed distribution expanded rapidly to northern China and eastern China during the program, even after the program was officially ended. Farmers in these areas planted the new varieties for a comparatively large scale, which played a crucial role in increasing the yield of grain crops and relieving the crisis of food shortage in China as a whole.

Table 5 Seed Distribution of Improved Varieties From the University of Nanking (26, pp.1-6)

Crop / Year	Cotton	Wheat	Corn
1923-1924	9, 966	5, 625	90
1924-1925	16, 132	5, 997	1, 200
1925-1926	20, 000	*	4, 000
1926-1927	9, 808	14, 063	4, 216
1927-1928	4, 739	12, 974	4, 000
1928-1929	12, 411	16, 876	990
1929-1923	6, 300	19, 528	3, 665
Total	79, 356	75, 063	18, 161

*no data that year

9. Training Program

The training of workers was one of the most important elements in the PIP. It was agreed that efforts to produce better crops would be of little value unless well-trained people could work independently and continue the program years after the last Cornell professor had returned home. (10, p.6)

The training was carried out by choosing breeders at different experiment stations to attend a series of summer institutes. Love attached considerable importance to the selection of participants. He asserted that the participants should possess at least three qualities: first, have a deep sense of service; second, they must be interested in agriculture; and third, the participants must have at least some knowledgebase on the growing habits and planting methods of local crops.[53] This summer institute was originally planned only members in the PIP. In 1926, there were 23 enrolled for full time work and 16 visitors who took part time work. However, with the increasing influence of the PIP, many organizations, such as missionary stations, government agencies, and colleges of agriculture, also sent their representatives to take part in the institutes every year. Certainly, the summer institutes greatly strengthened the work that were being undertaken with mission, private, and governmental experiment stations across China.[54]

The three-week intensive workshop included formal lectures in the college, field observation trips, and informal discussions and conferences. As Myers discussed at the summer institute of 1931, the purpose of the summer institutes was to enhance working efficiency by formulating experimental methods and exchanging experimental materials, and meanwhile arousing people's interest in agricultural studies.[55]

The first summer institute was conducted by Myers from July 12 to August 4 in 1926; the second was directed by Love in 1929; the third was held from July 18 to August 5, 1930, at Yenching University under the direction of Wiggans; and the fourth was held from July 6 to 24, 1931, under the direction Myers.[56] Among the 91 regularly registered students and 20 visitors to the summer institute in 1931 (except for the 24 upper-classmen of Nanking) all were engaged in teaching or experimental work at their respective institutes. (17, p.37) This revealed the high academic level of the summer institutes. For these Chinese students, this institute served as a Graduate School of Agriculture in the field of plant breeding. During the summer institutes, intensive courses of instruction in genetics and plant breeding and related subjects were offered to the Chinese students who had little or no training in these fields. In addition, the summer institutes brought the cooperators together to discuss the problems arising at their stations and to suggest measures to address various problems. By the end of the formal cooperation between Cornell and Nanking, it was estimated that over 125 men, who had little or no previous experience, had been trained to independently conduct crop improvement experiments. (10, p.42)

III. Significance and Influence of the PIP

In the field of modern agriculture in China, the success of the PIP proved that the integration of the trinity of agriculture production, scientific research, and education could be transferred from the United States to China. In this system, the cooperative stations took the responsibility for distributing the improved varieties to farmers, at the same time, extension workers at these stations conducted research and demonstrations of improved crop raising methods. The distribution work was conducted at the county level, however, the Nanking central station frequently kept contact with these local stations to direct their work. (Love, Harry, H and Chen Yanshan, 1931, 391-394) The university was responsible for selecting new varieties, studying experimental methods, and training researchers. All the cooperative stations took charge of conducting experiments, collecting data, and doing distribution work. The value of this systematic cooperation is the same varieties or selections of plants can be tested at different regions of China under different conditions and if any varieties appear superior at one of the cooperating stations, they can be made immediately available for trial by all the stations and the CAFUN in the nationwide system. This new mechanism following Cornell's pattern of the integration of agriculture production, scientific research and education became standard practice in China. The University of Nanking also placed increasing emphasis on experimental study and field research. As a result, other colleges of agriculture in China began to imitate the CAFUN's integration of agriculture production, scientific research, and education.[57] This greatly contributed to the overall development of agriculture in the period of the Republic of China.[58]

The PIP has exerted considerable influence on the follow-up work at Cornell. The Cornell agricultural experts taught scientific methods and theories on agricultural education and research in China which enhanced CAFUN's scientific research work. In addition, they all expressed same appreciation that the improvement work in China also enriched their experience and research techniques brought back to Cornell.[59] This kind of win-win cooperation met the agricultural research, extension, and educational needs of both Cornell and Nanking, which laid the foundation for later international cooperation in the field of science and technology via different channels between Cornell and other universities worldwide. As

Prof. W. I. Myers, former dean of the CACU, stated in a letter, "The success of the Cornell-Nanking program was one of the factors that leading to a decision on the part of the New York State College of Agriculture at Cornell to undertake an extensive program in cooperation with the College of Agriculture at Los Banos, in the Philippine Islands." (10, p.56)

In China, before the PIP, both in academic communities and business circles, people were grasping at phony solutions to low food production and starvation, such as blind introduction of foreign varieties into China and promiscuous plantation with no scientific guidance. The PIP attempted to correct this false worship. Love contended that although planting foreign varieties was a way to improve wheat production in China, planting experiments had to be conducted on a small scale first to achieve the best results.[60] So the Nanking Station and all cooperative stations conducted many experiments with foreign varieties to determine which varieties were adaptable to local climate, soil conditions, and planting traditions in China. Taking China's geographical conditions, rural situations, and material needs into consideration, the faculty and students at the University of Nanking conducted the PIP with the latest scientific methods, making effective improvement on crop varieties as well as greatly benefiting farmers in China.[61]

The PIP was also a successful case of educational assistance.[62] This program both directly and indirectly trained a group of crop specialists who devoted themselves into the modern agricultural industry in China. As Love once pointed out, the PIP was one of the biggest ventures not only in China but also in the world where so many men worked together toward one common end. After the program ended, some of these PIP staff remained at the university as faculty or staff, as well as some of them went to the cooperative stations to continue their work. Also, many of them went to universities in the western countries, especially the United States, for further study. Many of them returned to China after receiving a master's or doctoral degree. These men made great contributions to the crop improvement work by sharing their advanced knowledge on crop breeding and genetics learnt abroad. They became the most important crop breeders during the Republic of China and even in the People's Republic of China, including Shou Wang (1897-1972), Wu Shaokui (1905-1998), Shen Xuenian (1906-2002), Dai Song'en (1907-1987), Xu Tianxi (1907-1971), Mei Jifang (1908-1983), Yang Hongzu (1911-1979), Sun Qu (1911-1975), and R. H. Ma (1912-1996)[63]

The PIP served as a model for agricultural cooperation with other countries during the middle and late period in the Republic of China. As the program developed, not only did the crop improvement work at the University of Nanking become standardized, but also National Central University, Yenching University, and Lingnan University began crop improvement research. Love's goal was to develop a national program for agricultural improvement to coordinate research work at provincial experiment stations and agricultural colleges of different regions in China.[64] Furthermore, the PIP stimulated the Chinese government to establish the National Agricultural Research Bureau of the Ministry of Industry in 1931 which made great improvements in agricultural production in China through scientific research and agricultural extension services later.[65] Influenced by the program, a series of official Sino-US exchange activities in modern agricultural technology occurred, such as the North China Council for Rural Reconstruction (1936-1943) funded by Rockefeller Foundation, the cooperation between the Chinese Ministry of Agriculture and Forestry and International Harvester Company (1945 -1948), and the China-United States Agricultural Mission (1946-1948)[66] All these exchanges and communications greatly promoted the agricultural modernization in China and international cooperation between China and the United States.

The PIP also has crucial significance in contemporary China's scientific research and education, and the international cooperation of science and technology. The breeding practices in agricultural science and technology invented in the PIP are often out of date now, but the triangular integration of agricultural production, scientific research, and education with Chinese characteristics developed in the PIP remains important for the advancement of agricultural research and education in China's modern society. However, since the revolution in 1949, a planned national economy prevented China's progress for productivity growth and international cooperation. Statistics have shown that the scientific and technological achievements in agriculture exced 6,000 specific innovations every year in China, while only 30 to 40 percent of which were transformed into productive forces and fewer than 20 percent formed effective impact.[67] Meanwhile, educational institutions, scientific research centers, and administrative sections cannot cooperate with each other. It is hard to change the current situation since they have been working independently for a long time. (57, p.119) Nevertheless, the PIP from the 1920s to 1930s provides a model for "industry-university-research cooperation" that the Chinese government has vigorously advocated for in recent years.

Last but not the least, the PIP had a unique contribution in the international cooperation of science and technology. It must be admitted that such cooperation in science and technology has increased the technology transfer from western developed countries to the developing countries, not only providing developed countries valuable practical experience of technique applications, but also improving people's livelihood in developing countries. As one member in the U.S. Department of State admired, the PIP "was one of basic reasons for the initiation of a more comprehensive program of cooperation between American colleges and their overseas counterparts as an important part of the technical aid program."[68] The PIP set an excellent example for international cooperation with mutual benefits in contemporary times.

Faced with international disputes of intellectual property and trade wars between China and the U.S., we should promote diversified channels of communication, including employing both sides' experts in one project that can benefit people in both countries, sending students to study in top universities of both countries, and establishing Sino-US joint research centers to foster scientific and technological cooperation. In the aspect of agriculture, the methods and philosophies that the PIP paved one century ago can point towards a solution for current disputes between the two countries.

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