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AGRICULTURAL RESEARCH IN CHINA*

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DURING the summer of 1936 the writer visited many of the agricultural research institutions in Central and Northern China and observed the nature and extent of the investigations under way. From published papers in other countries which refer to work in China, such as the yearbook for 1936 of the United States Department of Agriculture which so adequately has summarized plant and animal breeding in the United States, it is apparent that there is little appreciation of the extent and nature of similar work in China. This is not strange, as until very recently there have been no adequate summaries in English. As the writer has been associated with leaders in agricultural research, affiliated with the Central Government of China or with various provincial departments and agricultural colleges, it seemed possible to make a survey that would give some idea of the nature and development of agricultural research in China in recent years. Data for this survey have been collected through correspondence with workers in various provinces and from members of the National Agricultural Research Bureau[1] in Nanking who are in touch with special phases of research throughout China. A summary by Director K. S. Sie,[2] of the National Agricultural Research Bureau, in the Chinese Year Book for 1935–36 has been of special value. The writer is greatly indebted to those who have so kindly made this information available.[3]

* Address of the vice-president and chairman of the Section on Agriculture, American Association for the Advancement of Science, Atlantic City, December, 1936.

[1] The Nat. Agr. Res. Bur. Ministry of Industry. Miscellaneous Pub. No. 1. 1934.

[2] K. S. Sie, "The Chinese Year Book," pp. 731–768. 1935–36.

[3] The writer appreciates the helpful suggestions of the following members of the National Agricultural Research Bureau and of the National Rice and Wheat Improvement Institute: K. S. Sie, T. H. Chien, L. F. Chao, T. H. Shen (see Proceedings 5th Pacific Science Congress, pp. 573–579, 1933, Univ. of Toronto Press, and "A Coordinated Program of Wheat Breeding in China," in press, 1936), C. L. Pan, F. C. Woo, P. T. Sun, C. C. Kwan, S. C. Cheng, H. Tai, N. F. Chang, W. S. Tong and K. Ling. Paper

Before discussing various lines of research and experimental work under way it seems desirable to make a few observations regarding farming in China.

SOME FARM PRACTICES IN CHINA

While agricultural research in China is of rather recent development, the art of farming has been well worked out through centuries of trial and error.

In most regions the farmers live in villages and a farm consists of non-contiguous plots, in unfenced fields, the plots of a single farm often being located at some distance from each other. The size of farm is small, and Buck[4] states "that for China as a whole the size of farm is probably well under five acres."

Most of the farm work is done by hand labor, including planting, cultivating, harvesting, threshing and in some provinces carrying the crop to market. In East Central China, for example, the crop from the field usually is carried to the farm home by means of a carrying pole over the shoulders; and the threshed grain may be transported to market by the same means. In the north farm products are carried by donkeys, horses or mules. In the vicinity of large cities the streets are often lined in the early morning with farmers carrying their produce to market. The amount of human labor used in the farm operations can hardly be appreciated by any one who has not observed the conditions.

The utilization of all forms of organic waste products as fertilizers has led to a permanent system of conserving soil fertility. Farm manures and some other forms of organic waste products are generally composted before being returned to the soil. In East Central China, where rice is the main crop, pond and canal mud often is applied to the fields in large quantities, while ashes from fuel are an important fertilizer also. Near the large villages the use of "night soil" has led to excellent crop yields, although those fields that are at some distance from the village frequently appear deficient in productivity.

Satisfactory systems of crop sequence have been developed and are in common use. While more intensive methods are used in China than in the United States, the yields of wheat, on the average, according to Buck, are about the same in both countries, while corn and cotton yields are greater in the United States than in China. Rice yields are approximately 50 per cent. greater in China than in the United States. This comparison is somewhat misleading, as the growing of two or more crops per year in China is a common practice where seasonal conditions permit. Thus in Shantung Province in the flue-cured tobacco region a common practice is to grow winter wheat and tobacco the same year on the same land, the tobacco being transplanted after the wheat is harvested. This system of double cropping is an interesting one, the crops being used varying widely according to local and seasonal conditions.

A few of the better systems described by Buck give an idea of methods that are common in several localities (see Table 1).

TABLE 1

Province	Kind of land	Year	Winter and spring crops	Summer crops
Anhwei	Low	1st	Barley	Soybeans
	"	2nd	Wheat and field peas	Sesame or soybeans
	High	1st	Wheat	Soybeans
	"	2nd	"	Sesame
	"	3rd	Kaoliang	
Kiangsu	Paddy	1st	*Astragalus sinensis*	Rice
	"	"	Wheat	"
	Low	"	Barley	"
	"	2nd	Field peas or broad beans	"
	High	1st	Wheat	Soybeans
	"	2nd	Wheat or barley	Sweet potatoes
	"	3rd	Field peas or broad beans	Corn and soybeans

A particularly intensive system noted in one section of Anhwei Province consisted of winter wheat, followed by rice. A week or two before the rice was harvested soybeans were sown broadcast in the rice fields, making three crops per year. In most of these illustrations a legume appears rather frequently in the rotations.

Interplanting of crops is a common practice. These consist, in some cases, of a legume grown in association with a non-legume. Examples are wheat and field peas used as a winter crop in one of the rotations, while barley and broad beans are grown frequently in alternate narrow plots. Early and late rice are handled in the same way, some farmers believing that larger yields are obtained than by growing either early or late rice alone.

Fuel supply for both farm and city population consists to a considerable extent of crop plants. Thus the stalks of corn and kaoliang are used extensively for fuel. Coarse grass and weeds in waste areas are cut and dried for fuel. It is a common practice in some sections of the North to harvest wheat and kaoliang plants by pulling them, using the roots as well as the stalks for fuel. These practices, which are common in the North, have reduced the organic content and humus of the soil; and while it is appreciated that this is undesirable, there is no other available supply of fuel for cooking and heating.

AGRICULTURAL COLLEGES IN CHINA[5]

Agricultural research depends in general on at least two main factors. First, there must be an appreciа-

No. 348 of the Miscellaneous Journal Series, Minnesota Experiment Station.

[4] John Lossing Buck, "Chinese Farm Economy." The University of Nanking. 1930.

[5] S. C. Wang, "The Chinese Year Book," pp. 456–532, 1935–36.

tion of the value of such research and facilities must be furnished for conducting the research. Second, there must be a group of trained men available for carrying on the research. It may be well, therefore, to make a summary of the number of agricultural colleges in China and of the student population and to speak briefly regarding advanced training.

According to the report of the Minister of Education, there were 1,683 graduates in agriculture and forestry in 1933–34 from universities, colleges and technical schools of college grade. These are listed in Table 2.

TABLE 2

Name	Location	Auspices
National Central University	Nanking	Provincial
National University of Peiping ...	Peiping	"
University of Chekiang	Hangchow	"
Sun Yatsen University	Canton	"
National Wu-Han University	Wuchang	"
National University of Szechuan ..	Chengtu	"
University of Kwangsi	Wuchow	"
University of Honan	Kaifeng	"
University of Nanking	Nanking	Private
Lingnan University	Canton	"
Fukien Christian University	Foochow	"
Nantung College	Nantung	"
National Northwestern College of Agriculture and Forestry	Wukung	National
National Technical School of Veterinary Science	Shanghai	"
Hopei Provincial College of Agriculture	Paoting	Provincial
College of Education, Agr. Dept. ..	Wusih	"
Tech. School of Agr. of Kiangsi ...	Nanchang	"
Tech. School of Agr. of Shansi ...	Taiyuan	"
Inst. of Kansu Junior College of Agriculture	Langchow	"

Of this list of 19 institutions, 7 receive mainly provincial support, 8 receive support from the National Government, and 4 are privately supported.

At present there are only a few institutions that give opportunity for graduate work. These are: Sun Yatsen University, that offers graduate work in agricultural chemistry and in agricultural botany; Central University, with graduate work in plant breeding; and the University of Nanking, with graduate work in agricultural economics. The number of graduate students at these various institutions is very small. For this reason most persons engaged in agricultural research in China must obtain their graduate training in foreign countries. This is expensive and without doubt has greatly limited the number of men taking graduate training. During 1929–34, according to the report of the Minister of Education, 207 Chinese students went abroad for graduate study in agriculture and forestry. It seems very probable that, with the rapid increase in agricultural research in China in recent years, there will be also a great increase in graduate training and that this will lead to the development of graduate work in those colleges and universities in China that are best fitted to give such instruction.

The Development of Agricultural Research in China

One indication of the interest in agricultural research is the development in recent years of extensive work under the National Government. Important institutions under the Ministry of Industry include the National Agricultural Research Bureau in 1931 and the National Rice and Wheat Improvement Institute, organized in 1935. The Cotton Improvement Institute was organized in 1934 under the National Economic Council. These three institutions are located about five miles east of Nanking, where adequate buildings and land have been made available. The Division of Agricultural Economics of the National Agricultural Research Bureau made a survey of the experimental work in agriculture in 1933, including institutions under national, provincial and other auspices. While data were not secured for all provinces rather accurate data were obtained for several provinces. These data consisted of the nature of the work, the date of organization and the number of technical workers. The summary given here does not include the staff of those institutions engaged primarily in teaching. The sort of data obtained may be illustrated by the following examples. The cotton experiment station of Nantung College was organized in 1932 and has a technical staff of 13, and the Provincial Wheat Station at Huschow was organized in 1917 and has a technical staff of 9.

The data presented in Table 3 are summarized by periods for the provinces of Kiangsu, Chekiang and Shantung.

TABLE 3

NUMBER OF RESEARCH STATIONS CLASSIFIED ACCORDING TO THE DATE THE WORK WAS INITIATED AND TOTAL NUMBER OF RESEARCH WORKERS (DATA COLLECTED IN 1933)

Province	Class for date of organization					No. of tech. workers
	Before 1915	1915–24	1925–30	Since 1930	Total	
Kiangsu ...	2	9	4	8	23	148
Chekiang ..		2	3	2	7	128
Shantung ..	1	4	1	3	9	60
Total	**3**	**15**	**8**	**13**	**39**	**336**

Of a total of 39 such research institutions in these three provinces, 13 or nearly one third have been organized during the last six-year period. These data, while not complete for all work organized since 1933, are sufficiently accurate to give a clear picture of the interest to-day in China in research and experimentation, which has as its aim the development of greater efficiency in agriculture.

The extent and nature of agricultural research in China will be discussed by summarizing briefly research in particular fields, including crop improvement, soils and fertilizers, plant pathology, entomology, horticulture, forestry, animal husbandry and veterinary science, and sericulture.

Crop Improvement: The breeding of improved varieties of crop plants and their distribution to farmers in China is without doubt the best developed of any line of agricultural work. This is due partly

to the organization in recent years of the National Rice and Wheat Improvement Institute, under the Ministry of Industry, and the Cotton Improvement Institute of the National Economic Council. For wheat, rice and cotton these national institutes are developing cooperation with various provincial institutions. Special training schools for technical workers have been held during the winter months, under the auspices of these institutions and the National Agricultural Research Bureau, which have given admirable opportunity for the development of coordination in research.

Recently the improvement of wheat in China has been placed on a coordinated basis through cooperation between the various agencies interested in wheat improvement. Cooperative regional trials, free exchange of materials and nation-wide nurseries consisting of the more important foreign and native varieties have been planned. The breeding for disease resistance is an important feature of this cooperative program. Similar programs are being organized for improvement work with rice, cotton, sweet and Irish potatoes.

The University of Nanking has had a great influence in the development of crop improvement in China. A project first initiated by Dean John H. Reisner, of the College of Agriculture of Nanking University, was enlarged in 1924 through cooperation between the University of Nanking, Cornell University and the International Education Board. Members of the staff in plant breeding of Cornell University directed the work and did much to create a nation-wide interest in China in crop improvement.

During the last summer the writer visited many plant breeding stations in Central and Northern China and was impressed with the large proportion of technical workers in plant breeding in these sections who are graduates of the University of Nanking. A recent report of the improvement project of the University of Nanking,[6] that has been extended to include cooperation with nine provinces and the National Government, describes three improved varieties of wheat, Nanking 2905, Kaifeng 124 and Nanhsuchow 61, an improved variety of barley called Kaifeng 313, Nanksoy 332 soybeans and an improved variety of native cotton called Million Dollar. Each of these varieties appears to be a great improvement in the section in which it is adapted over the native varieties now grown. These and other improved varieties are being increased rapidly.

Workers at Central University have been leaders in cotton and rice improvement; and, through cooperation between Central University and other institutions, several valuable varieties of cotton have been introduced from America and are being grown widely in China.

A partial picture of the extent of crop improvement work in China can be gained by listing the number of experiment stations working on crop breeding in China, as given by Sie, and the crops being worked with. These consist of 56 stations that are breeding cotton; 48, wheat; 38, rice; 15, millet; 17, kaoliang; 17, soybeans; 16, corn; and 37, miscellaneous crops. Extensive studies with tea, including tea improvement, are being carried on in Southern and Central China. From statistics gathered from experiment station workers in various provinces, it seems safe to conclude that there are from 5 to 20 project leaders in most of the provinces that are giving their entire time to studies of crop breeding. Each of these leaders has an average of 2 or 3 assistants, approximately half of these being graduates of agricultural colleges.

The field work at the institutions visited by the writer was well carried out and the extent of field trials fully as great as at similar institutions in the United States.

Soils and Fertilizers: The Colleges of Agriculture of Central University, Sun Yatsen University, the University of Nanking and the University of Chekiang have comprehensive courses in soils and fertilizers; while the Colleges of Agriculture at Nantung, the University of Peiping and the Provincial Universities of Hopei, Honan, Anhwei and Kwangsi also give course work in this field. Some of these institutions are well equipped and have rather extensive research under way on various soil and fertilizer problems, comprising field experiments with both organic and inorganic fertilizers, analyses of soils and manures, studies of alkali soils and other problems of local interest.

The Department of Soils and Fertilizers of the National Agricultural Research Bureau with a technical staff of six men have extensive field experiments in seven different provinces, in cooperation with 20 local experiment stations, and are studying fertilizer problems with wheat, rice and cotton. Besides comparing the value of N, P and K alone and in varying proportions, studies are being made of different kinds of organic and inorganic fertilizers, the effects of acidic-inorganic fertilizers when used alone, with lime, with organic manures or both and the residual effect of fertilizers on the succeeding crop.

Very few rotation experiments have been carried on in China, although in many cases the farmers have adopted what appear to be desirable sorts of crop sequences. In recent years the Soils Department of the National Agricultural Research Bureau has initiated several rotation studies in cooperation with local stations.

The Provincial Experiment Station of Chekiang

[6] H. H. Love, T. H. Shen, L. Y. Ma, R. V. Pih, Sheo Wang, S. P. Peng and Y. S. Chen, College of Agr. and For. Univ. of Nanking. Special Report No. 2. 1935.

has started recently comprehensive studies of soil and fertilizer problems with a technical staff of about 15 men. They are making comparative studies of available plant foods in the soils of their province by the following methods: (a) Mitscherlich's pot experimental method, (b) Neubauer's method, (c) the citric-acid method and (d) microbiological methods. They are using field experiments also for the direct study of the value of fertilizers.

The Cotton Improvement Institute of the National Economic Council is making rather extensive studies of manurial experiments in relation to cotton culture. A technical staff of two men is directing these experiments in various regions where cotton is of importance.

A soil survey was started in 1930 in East and Central China by C. F. Shaw, of California. This work was arranged by Dr. Buck, of the University of Nanking, to aid in a survey of land utilization. The work was continued by the Soils Division of the National Geological Survey of China under the direction of Robert L. Pendleton for a two-year period. Special bulletins called "Soil Bulletins" are published by the geological survey. In 1933 James Thorp from the United States was placed in charge of the soil survey. Ten assistants have aided in the studies and a comprehensive summary of the results of the survey is now in press. The work will be continued under the leadership of K. C. Hou.

The Provinces of Chekiang, Kwangsi, Kiangsu and Kwangtung have established their own survey program and a great deal of work has been done in Kwangtung Province.

This rather brief summary emphasizes the extent to which studies of soils and fertilizers have been initiated in recent years. The present indication is that this phase of agricultural research will be expanded further in the near future.

Plant Pathology: According to the report of K. S. Sie in the Yearbook for 1935–36 work in phytopathology was initiated in 1924 and since that time there has been rapid progress. The Phytopathological Society of China was organized in 1929 and now has 36 regular members. Approximately half of the agricultural colleges in China have well-organized departments or laboratories of phytopathology. Rather extensive surveys have been made of the diseases of the more important crop plants, including studies of fruit diseases and of some vegetable diseases. Methods of disease control worked out in foreign countries or in China have been made available to farmers.

Studies of disease resistance have been or are being made, including resistance of millet varieties to smut and downy mildew, resistance of wheat to flag, stinking and loose smuts and resistance of barley to covered smut. Reports of progress show the value of breeding for disease resistance. In recent years studies of resistance to leaf and stripe rusts of wheat have been started at the National Agricultural Research Bureau. Native varieties are susceptible to both diseases, for the most part, but many foreign varieties from both Europe and America are highly resistant.

Copper carbonate dust and other seed disinfectants have been used successfully to control some of the smuts of cereals.

(To be concluded)

OBITUARY

J. ERNEST G. YALDEN

THE sudden death of J. Ernest G. Yalden, of Leonia, N. J., of a heart attack on February 22, 1937, has taken from the number of scientific workers a remarkable individual. A man of wide interests and unusual ability, he developed as an avocation such skill in those matters which attracted him that he became perhaps better known for his work at home than for the distinguished service which he gave in the field of practical education.

Born in England in 1870, Yalden received his early training in the typical boys' school of the period, to be followed by a course in civil engineering at New York University, from which he graduated in 1893. After a few years in the practise of his profession, he was encouraged to submit to the trustees of the Baron de Hirsch Fund a plan for the trade school which they were contemplating. His ideas were so well thought out and so well organized that he was invited to put them into operation.

He thus became the first superintendent and moving spirit of the school, which, until its recent absorption by the New York City system, operated most successfully along the lines indicated in the original plan. The reports of the school written during this period have been carefully studied by those concerned with training for craftsmanship, and many of the ideas have been put to use elsewhere.

Yet the native curiosity of the man and its accompanying thoroughness led him through a host of other experiences which were to profit many besides himself. An enthusiastic yachtsman, he designed and built various boats, from canoes to sea-going yawls, one of which, named by him the *Hippocampus,* has figured in boating literature.

A lover of boats who was fond of mathematics could