AD 673507

TRANSLATION NO. 1577

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DATE: 8 December 1965

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THE CIRCUMSTANCES AND PROGRESS ON THE BREEDING OF RUST-RESISTANT WHEAT

Chinese Agricultural Sciences,
No. 8, Peking, 1964, pages 12-19

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Rust is an important disease of the wheat in China. Breeding and promoting rust-resistant varieties has become one of the major means of obtaining a rapid increase of the wheat production. Since the liberation, under the correct leadership of the party and the government, the work of breeding rust-resistant wheat varieties has been very successful, but in some areas, problems and shortcomings still exist. Hence, it is necessary to review our past experience on this subject so that items and problems in need of attention may become clarified, and the work may be quickly improved to bring even greater effects on the grain production. This is the wish of every one whose task it is to breed rust resistant varieties. The following is my personal knowledge of the subject; corrections from the readers are invited.

I. Practical Meaning of the Work of Breeding Rust-Resistant Varieties

Rust is a major disease of wheat, but the disease does not prevail regularly in all places. Its occurrence is determined by the weather conditions of the locality in a certain year and the quantity of disease-causing organisms of the fall shoots the preceeding year. The concrete rule in the regions of North China appears to be the rainfall and the humidity condition of early spring. For example, in the upper reaches of the Huai-ho, such as the southern and central parts of Honan, spring rain is normally plentiful, and the over-wintering bacteria are usually numerous; therefore, the condition is especially favorable for the occurrence of the disease. It has now become the nest of strip rust disease in North China. The bacteria regularly spread from that area. In other areas, however, rust damage does not happen every year.

Generally speaking, the harvest of wheat in the northern part of North China is closely related to the precipitation of early spring, and spring drought has regularly been the major factor for the unstable yield of wheat. It is only occasionally that the early spring is favored with a good rain; then, that year should be a year of good wheat harvest. Such a year, however, is usually a good year for the rust disease also, and the possible good harvest is thus regularly damaged. Hence, the control of the rust disease is one of the key problems for stabilizing wheat yield in North China.

Of the three rust diseases, the strip rust disease does the major damage to the winter wheat of our country; it is also the most prevalent. A serious loss was suffered in 1950 in all wheat producing regions of our country with an average yield reduction of 20-30% due to strip rust. Since then, localized damage occurred very frequently to cause losses of various degrees. It was the western part of Szechwan in 1951; central part of Shansi and Inner Mongolia in 1952; central part of Shansi and southern part of Honan in 1953; central part of Hopei and northern part of Kiangsu in 1954; central part of Hopei, southern part of Shansi, and Lo-yang, Hsu-ch'ang, and Cheng-chou of Honan in 1955; southern and western parts of Kansu and parts of Honan in 1957; Kuan-chung of Shensi and central part of Honan in 1958; central part of Shansi and southern part of Honan in 1959; Honan in 1960; Honan Kuan-chung of Shensi, and eastern and southern parts of Kansu in 1963. The disease was serious in these areas in those years, and the yield was appreciably affected.

The stem rust disease is mainly a serious threat to the spring wheat areas. It caused great losses in various areas of the Northeast in 1948, 1951, 1952, and 1956. The loss due to this disease was as great as 70% in Inner Mongolia in 1956. In recent years, it is beginning to become a serious threat to winter wheat also. For example, it prevailed on a great scale in Kiangsu and Anwhei in 1956 and 1958, and the loss was about 20-30%. In a few localities in Shantung and in Fukien it also occurred regularly.

The leaf rust disease is not a threat as far as North China is concerned; however, due to continued improvement of cultivating techniques and rapid enlargement of irrigated acreage, its threat is gradually becoming serious enough to warrant attention.

There are many ways of controlling wheat rust, and all of them should be emphasized; however, production practice has provided powerful evidence that breeding rust-resistant varieties is the most effective and the most economical way to control this disease or to reduce its damage.

II. Current Condition and Achievement of the Work of Breeding Rust-Resistant Varieties

Since the liberation, the work of breeding rust-resistant wheat has made great progress. Many rust-resistant varieties have been acquired and promoted, and they have affected production a great deal. The breeding method has been greatly improved also. This improvement may be described in the following three aspects:

(1) Introduce Superior Rust-Resistant Varieties and Promote them Rapidly:

In our country, the work of breeding rust-resistant varieties began with selection. A large number of varieties were observed and compared to determine their yield and rust-resistance, and from this work many rust-resistant varieties, such as Pi-yu-mai, Chung-nung 28, Nan-ta 2419, and Ai-li-to were obtained, and they were immediately recommended for popular use. The use of these superior rust-resistant varieties was very limited, however, until the liberation. Since then, efforts were made to introduce these varieties for extensive use. For example, Nan-ta 2419 was introduced to 90,000,000 mou, which amounted to more than 1/5 of the total wheat acreage of the country. Meanwhile, these varieties were identified as superior parent-pure hybrid lines, and their offspring were also recommended for extensive use.

Since the liberation, more rust-resistant varieties have been selected. They were Nung-ta No. 1 (Tsao-yang-mai), Nung-ta No. 3 (Ch'ien-chiao-mai), 3002, 2037, Wu-k'o-lan 0246, New Wu-k'o-lan 83, and others. Some of them were introduced to several tens of thousand mou, and others were introduced to several million mou. The most recently verified rust-resistant varieties were Tsao-shou No. 1. Chi-li, Ai-kan-hung, A-fu, and A-po, all of which have been recommended to the suitable areas. (Most of the above varieties are resistant only to strip rust, and a few of them are resistant to leaf-rust and stem rust also.)

For the spring wheat areas, the varieties that have been introduced are Kansu 96, Mai-li-to, Pai-lo-t'u, Sung-hua-chiang No. 1, and No. 2. The old favorite spring varieties such as Pi-yu-mai have been continuously spread in the central and southern parts of the country as well as Ning-hsia. The new variety, A-po has been found to be good for the winter wheat areas as well as the spring wheat areas, and has been recommended for use in both.

(2) Breed and Promote the New Rust-Resistant Varieties:

Hybridization is an important method of breeding rust-resistant varieties. The work of hybridization began in our country in 1936, but a full-scale effort was exerted only after the liberation, and not a few

have been obtained since then. For example, Pi-ma No. 1, Pi-ma No. 4, and Hsi-nung 6028 have already contributed to yield increase. Of these Pi-ma No. 1 has been widely distributed in the northern part of North China, in an acreage as large as 90,000,000 mou at one time. Together with Nan-ta 2419, Pi-ma No. 1 is also one of the varieties that covers the largest acreage in our country. Since 1957, however, its rust-resistance began to wane, and its acreage has also been reduced.

The National Wheat Rust Conference was called in 1950. Breeding experience and original data were exchanged at the conference, and experimental regions were arranged to promote the work of breeding rust-resistant varieties of wheat. Since then, the various agencies have considered rust-resistance as one of the major goals of their breeding work, and in the years between 1956 and 1959, a large number of superior varieties were obtained and recommended for production.

In the winter wheat regions of the north, there are Nung-ta 183, Nung-ta 36, Nung-ta 498, Hua-pei 187, Hua-pei 497, Hua-pei 672, Shih-chia-chuang 407, T'ai-yuan 566, T'ai-ku 49 (the above make up the Sheng-li Yen-ta series), Nung-ta 90 (Yen-ta 1817 x K'ai-hung), Hsin-shih Hsiao-mai (Yu-tzu-mai x Mei-mai No. 10), and T'ai-yuan 567 (Nung-ta 498 x Tsao-yang-mai).

In the winter wheat regions of Central China, there are Cheng-chou 808 (Pi-yu x Ho-ta H4), Hsi-pei 612, Hsi-pei 141 (the above make up the Pi-ma x 6028 series), Hsi-pei Feng-shou-mai (Hsi-pei 302 x Pi-yu), Hsi-pei 54 (Hsi-pei 302 + → Hsi-pei-chan No. 2), Nei-hsiang No. 5 (Nan-ta 2419 x Paiyu-p'i + Pai-huo-mai + Hsiao-pai-mang-mai), Hua-chung No. 10 (Ai-li-to x Sheng-li), Shan-nung No. 3 (Yuan-ch'ui-hsiao-mai x Yu-txu-mai).

In the Yangtze Valley, there are Szechwan 51 mai (Ch'eng-tu Kuang-chien - Ai-li-to x Ch'uan-fu - Pi-yu), Shan-nung 205, Hau-tung No. 6, and Hua-chung No. 4.

Generally speaking, the above varieties have stronger stems. They are rust-resistant, fall-resistant, and have larger grain and better adaptability. Their yield is higher and stable. The areas to which they have been introduced vary in size, and to this day, they do not cover a very large acreage. Some of them have recently been found to have waning rust-resistance, and their value has thus declined. In production, however, superior varieties are being multiplied everyday.

In the Northeast, the rust-resistant varieties that were bred and introduced were Ho-tso No. 1 to No. 7. They have been recommended to various areas of that region since 1954. Together with some selected varieties such as Kansu 96, and Sung-hua-chiang No. 2, they have basically controlled the rust problem of that region. The production of the spring wheat has thus been greatly stabilized, and the use of these varieties

has thus been spreading very fast. In 1956, the superior varieties became more or less the common varieties in production in that region.

Since the great leap forward of 1958, the work of selection and breeding of new wheat varieties has been further strengthened. The goal of the breeding work was by then clearly defined to be that of rust-resistant varieties, and the source of the parent-pure varieties was duly enlarged. The emphasis was now on the selection and hybridization of these parent-pure varieties that were immune to the disease, and the number of individual hybrids was increased. Individuals of each generation were strictly selected, and the yield was determined. Tests were conducted in many areas, so that the new superior varieties could be verified quickly. We must point out that the Institute of Crop Breeding and Cultivation of the Chinese Academy of Agricultural Sciences, the Crop Research Institute of Shantung Provincial Academy of Agricultural Sciences, and Honan Provincial Academy of Agricultural Sciences combined Pi-ma No. 4 and Tsao-yang to obtain the rust-resistant varieties of Peking 8, Chi-nan 2, and Cheng-chou 24; Hopei Provincial Institute of Wheat of Shih-chia-chuang combined Sheng-li and Shih-t'e 14 to obtain Shih-chia chuang 52; the Kiangsu Branch of Chinese Academy of Agricultural Sciences combined Ai-li-to and Sheng-li to obtain Hua-tung 10, etc. All of these are resistant to the strip rust subspecies that is damaging Pi-ma 1; their yield is high; and they are adaptable to many regions. They are now being introduced in the winter wheat regions of North and Central China to replace Pi-ma 1 and Pi-ma 4. Besides, Peking University of Agriculture is continuously working on the hybridization project of combining Yen-ta 1817 and Sheng-li to obtain Nung-ta 311 which has been identified as resistant to the strip rust subspecies 1 and the demonstration and recommendation of which has already begun in the suburbs of Peking.

In the Northeast, the hybridization method has been used to obtain the stem rust-resistant, spring wheat varieties of K'o-chiang, K'o-chuang (the above make up the Ming-ni 2759 x Ho-tso 4 series), Tung-nung 101 (Sung-hua-chiang 1 x Lan-shou), Kung-chiao 102 (Ming-ni 2752 x Ho-tso 2). They have been recommended and popularized since 1958.

(3) Improve Methods in the Work of Breeding Rust-Resistant Varieties:

As the work of breeding rust-resistant varieties develop, the method is also improving. The improvements may be described as follows:

1. The goal is now [illegible]er than ever. Many agencies are now working with the consideration of the climate, the terrain, and the special cultivation system of their own locality. Each of them is breeding varieties specially suited for its own locality and is identifying the products into those most suited for one locality, and those suited for an entire region. The goal of the breeding work is now both specific and

diversified, and special emphasis is given to the different rust diseases. For example, in Anhwei, the goal is to obtain varieties resistant to the strip rust disease for the area north of Huai-ho and varieties resistant to the stem rust disease for the area south of Huai-ho, and other rust diseases are also taken into consideration. In East China, the goal is to obtain varieties resistant to the three rust diseases as well as to frost, and they must also be early ripening. In Shensi, the consideration includes the soggy fields and the dry fields, as well as the swamps and the tableland. The varieties must be combined and arranged to meet the diversified needs of the various areas. At present, some benefit has already been obtained from the improved method, although in view of the overall situation, appreciable effect still awaits the future. It is certain, however, that a large group of new varieties will soon appear and will generally have superior characteristics and will each be suitable for certain special conditions of each locality.

2. As the work in plant protection and physiological subspecies progresses, the work of breeding rust-resistant varieties has been placed on the basis of physiological subspecies. Many agencies are not considering varieties resistant to strip rust or stem rust. The problem is now to obtain varieties that are resistant to strip rust subspecies 1, 8, or 10, or to stem rust subspecies 21 or 34. In some cases, based upon the principle of occurrence of the rust diseases, a single subspecies or several subspecies are being considered as the target for a certain area. There is also consideration of a physiological subspecies that has not yet been discovered in a certain locality, but that is likely to occur in the future. In this manner, the work has progressed much further. It is, compared with the work method of the past, much more profound and detailed.

The work of verifying rust-resistant characteristics of original materials is also placed on the basis of the physiological subspecies. This work, for example, is being carried out by the Institute of Plant Protection of Chinese Academy of Agricultural Sciences, the Department of Agriculture of Peking University of Agriculture, Shen-yang Agricultural College, and the Kiangsu Branch of Chinese Academy of Agricultural Sciences. Some thousands of original materials have been identified on the basis of subspecies, and some have been found to be resistant to several subspecies or several different rust diseases. It is regrettable that the work of identifying the physiological subspecies of the leaf-rust has not yet been developed. At present, this type of bacteria is identified only by locality; for instance the Hopei type or the Shansi type.

3. In the past the hybridization work was conducted by the use of a single variety cross. Many agencies are now working with the outbreeding or the inbreeding methods. The limitation regarding the parent-pure varieties has thus been changed. At present, the yield of some offspring of inbred varieties is being compared before they may be verified.

4. In the spring wheat regions, some agencies are using greenhouses for the purpose of breeding so that two to three generations may be bred in one year. The success of this method has greatly shortened the time requirement in breeding work.

5. On the basis of summarization of breeding data, some agencies are analyzing the genetic principle of rust-resistance, and have determined the ability of the parent variety to pass on its disease-resistance to its offspring. For example, the study of Peking University of Agriculture shows that eleven varieties such as Virdniliyu, Yubilyeitsa, Elia, Frontana, Owest, Magnit, and Shui-yuan are very capable of passing on their resistance to strip rust subspecies 1 to their offspring. The rust-resistance of Elia is found to be a dominant characteristic while that of Early-ripening L-1 of the Soviet Union is recessive.

Besides, the genetic principle of other characteristics has also been summarized and analysized. For example, the genetic principle of early ripening was analyzed by Peking University of Agriculture, and a method has been found for predicting the characteristic of the offspring of being early or late according to the characteristics of the parent varieties. It has been suggested by Hsi-pei University of Agriculture that frost-resistance of the mother variety has a greater chance of being the dominant characteristic.

The selection effect of the various characteristics has also been summarized. For example, Lin Tso-i (2651 0155 2253) and Chang Shu-chen (1728 2885 2830) separately have worked with the effect of selection on such characteristics as early-ripening, long heads, number of spikelets, effective heads, and the weight of 1,000 seeds of the offspring. Of course this type of work has just begun, but it has already opened new pathways for the work of selecting parent varieties for breeding purposes, and the work of selection of the hybrids.

III. Current Problems in the Work of Breeding Rust-Resistant Varieties and the Work of Promoting These Varieties

Although much has been gained from the more than ten years' labor of breeding rust-resistant wheat varieties in China, some shortcomings and problems still exist. Some of these have been improved since they were called to attention, but it is still necessary to review these shortcomings and clarify some problems for future improvement. The shortcomings and problems, generally speaking, belong to the following aspects:

(1) The cultivating conditions are different from the production level practiced in the fields of large acreage.

The cultivation standard has been gradually raised since the liberation, and production requirements have also been gradually changed. The

past requirements of frost-resistance, drought-resistance, and thin soil-resistance are in the process of transferring to a requirement of high yield and rust-resistance of the varieties suitable for high level cultivation standards. This transition is very much in keeping with the laws of progress; however, there is always a time when the research agencies overemphasize the heavy fertilizer and irrigation standard in their selection and breeding of crop plants with the hope of producing new varieties that will not fall with a 1,000 chin yield, while the realistic requirements of the large fields are all but neglected. The level of cultivation of many experimental stations brings a yield from the varieties they produce as high as 600, 700 chin, or even 800 chin per mou, but as a result, these varieties often do not perform very well under the cultivation condition of the large fields. In this manner, the work of plant breeding is to a certain extent separated from production. Although there are many new varieties, those that are sufficiently adaptable to production are in short supply.

On the other hand, many of the originally low yield varieties have long since been replaced by the high yield varieties that have been promoted, but these new superior varieties cannot produce a stable yield when the natural conditions are not favorable.

In 1961, the National Wheat Breeding Conference proposed the thesis that the cultivation level of the experiments has been too high; therefore, this problem has been called to the attention of the agencies, and has been corrected. Currently, many of the agencies work with the production level of the local large fields, and emphasize the work of breeding the varieties that are suitable for the cultivation level of their locality, with due consideration of the high yield varieties and the varieties that are suitable for the low fertilizer and irrigation levels.

(2) Overemphasize a Single Variety and Confused Profusion of Varieties:

Since Pi-ma 1 and Nan-ta 2419 were promoted over large areas, in many places, there has been only one variety. The production practice of the last few years proved that this is not a favorable condition for stable yield, labor utilization, or prompt harvest. Moreover, this is the condition that will cause the degeneration of the rust-resistant characteristic of the variety. The regional conference of the Northwest of 1957 suggested a combination arrangement of varieties and a rotation system among the varieties, and in recent years, attention has been given to the coordination of the superior varieties. Some areas, however, are behind in their breeding work, and cannot find varieties that are suitable for their localities, or in some cases, there are not enough seeds to rotate the varieties; therefore, the phenomenon of a single variety still exists. This is a situation that demands a quick solution.

In some areas the superior varieties are in a confused condition. Some of these varieties have lost their original appearance. In the field of disease-resistant varieties, we can regularly find diseased individual plants that are the result of mechanical mixing or accidental hybridization. After years of planting, this situation often causes a good disease-resistant variety to lose its disease-resistance, and become an inferior variety. Due to the fact that there is a profusion of natural hybrids to serve as a comfortable bridge for the disease causing bacteria, one of the important measures to be taken for the prevention of the disease-resistant varieties from losing their resistance is to eliminate the possibility of such form of mixing.

(3) Superior Varieties May Not Be Superior; the Difficulties of Promoting Them:

Some agencies practice regional experiments in the course of breeding new varieties. The conditions of management, cultivation, and selection often do not match scientific requirements, and they are often too eager to produce. Consequently, their products often cannot withstand the test of production. On the other hand some of the truly superior varieties cannot become established due to the lack of large fields for seed cultivation. The productive coefficient is thus so low that there are not enough seeds to promote them over large areas to bring about a quick effect on production.

(4) Limitations of the Disease-Resistant Parent-Pure Stalks:

Foreign and domestic data all indicate that the search for disease-resistant or immune varieties to serve as the parent pairs for hybrids is the foundation of the work of breeding rust-resistant varieties. At present, the disease-resistant parent pairs of the northern winter wheat region are limited to those that were promoted for quantity production or those that have newly been promoted in the locality. They are for example, the Pi-ma series and the Sheng-li x Yen-ta 1817 series bred from the parent pairs of Pi-yu, Chung-nung 28, Tsao-yang, Sheng-li, Nan-ta 2419, and Early-ripening L-1. In the winter wheat region of the south, they are limited to the 20H155, Nan-ta 2419, Chung-nung 28, Ai-li-to, P223, P224, P225, and Li-ying series. It is very regretable that parent pairs are in short supply.

The lack of parent pairs is not simply due to the fact that there is a deficiency of rust-resistant materials. It is rather due to the lack of rust-resistant varieties that also possess other suitable characteristics. Currently some agencies have begun to use the outbreed and inbreed methods to overcome this limitation. For example, Hsi-pei College of Agriculture has made use of tsao-hung-yu which is extremely early-ripening to pair with Tan-mai 1 which is extremely late ripening, to obtain a disease-resistant

and not so very late hybrid, which is used as a material for further hybridization. Peking University of Agriculture has also started its work of outbreeding and inbreeding methods.

(5) The Changes of the Subspecies of Rust Bacteria and Loss of Disease-Resistance of the Wheat Varieties:

The loss of disease-resistance due to the changes of the physiological subspecies of the bacteria is a major problem facing the workers of the breeding task. Generally speaking, after a disease-resistant variety has been promoted over large areas, it often causes the subspecies to change, and the appearance and spread of the new physiological subspecies in turn often causes the variety to lose its disease-resistance. The loss of disease-resistance of Pi-ma 1 is an outstanding example. After the appearance of rust spores on individual leaves of Pi-ma 1 in Shensi in 1954, its disease-resistance disappeared in a very few years. According to surveys, the strip rust bacteria that damage Pi-ma 1 existed in Kuan-chung only in 1957, but by 1959, they prevailed in all the large areas where Pi-ma 1 was planted. Strip rust was suffered in the vast region from the southern part of Hopei to the southern part of Honan, from Kansu to the northern part of Anwhei to cause various degrees of crop losses. Worst of all, as the new subspecies spread, many disease-resistant varieties also lost their resistance. Thus, Pi-ma 4 also lost its resistance partially, and the same fate hit all the descendants of the Sheng-li 1817 series, such as Nung-ta 183, Nung-ta 36, Nung-ta 498, Shih-chia-chuang 407, Hua-pei 187.

According to the study of the Institute of Plant Protection, Chinese Academy of Agricultural Sciences, the cause of the loss of disease-resistance of Pi-ma 1 is the change of the composition of the subspecies of strip rust with the result of a quick spreading of strip Chung 1. The problem became even more serious since the latest change in the make-up of the strip rust bacteria. As the ratio between subspecies 8 and 10 rises, the vulnerable varieties of the past become disease-resistant, such as Ching-hui 26 and Ching-hui 30. Meanwhile, the varieties that were resistant to subspecies 1 have now become susceptible. For example, such famous varieties as Nan-ta 2419 have now partially lost their resistance in certain localities. According to surveys in Szechwan in 1962, Nan-ta 2419 was infected there, and the disease was very severe in 1963 in Ch'eng-tu plain and in Yunnan. Judging from the incident concerning Pi-ma 1, this new situation will perhaps start to spread also. Thus, to find a solution to this problem is one of the most important tasks of those who are engaged in the work of plant breeding and plant pathology.

The changes in the physiological subspecies of rust organisms make the work of breeding disease-resistant varieties that much more complicated and difficult. In the future, the scientists must expose the factors that cause this change so as to understand the make-up of the physiological subspecies, their distribution, and the direction of their change in order to

breed wheat varieties that are resistant to certain subspecies which are likely to occur, and varieties that are resistant to many subspecies.

IV. Problems to be Emphasized in Future Breeding Work

In order to further improve the work of breeding rust-resistant species, attention must be given to the following problems:

(1) Strengthen the Cooperation Between Plant Pathology and Plant Breeding Work so as to Make Full Use of Rust Research:

The work of breeding rust-resistant varieties includes the subjects of plant breeding and plant pathology. The close cooperation of the two is necessary to make any progress in this work. Today as the new physiological subspecies continue to appear and change, we cannot stay away from these physiological subspecies in our work of identifying our raw materials, the pairing of the parents, the selection of the hybrids, or the study of the genetic principle of rust-resistance. Thus the breeding work must be coordinated with plant pathology work every step of the way to collect the samples of the microorganism, to store them, identify them, culture them, and to inoculate them in the greenhouse or in the field. Assistance must be sought from the science of plant pathology in order to decide whether to inoculate a single strain of the organism or a mixture of strains, and to decide which physiological subspecies should be made the target. We must understand the distribution, composition, and the condition of existence of the various subspecies of this microorganism before we can draw up a correct design for the breeding work. In a sense, when there is no progress in the study of the rust disease, there can be no advance in the work of breeding rust-resistant varieties. The former is the antecedent of the latter.

Much has been achieved in the pathological work of the rust disease, but the accomplishment is still insufficient as far as the need of the work of breeding rust-resistant varieties is concerned. For example, the work of identifying the host of this microorganism is not completely satisfactory. According to Shen-yang College of Agriculture and the Institute of Plant Protection, Chinese Academy of Agricultural Sciences, both stem rust 21 and strip Chung 1 have very varied appearances. The identification of the physiological subspecies must be further improved to become the foundation of the work of breeding rust resistant varieties. The work of identifying the physiological subspecies of leaf rust still awaits a beginning.

Besides, at present, the hosts are always identified during the sprouting stage, but the reaction of many rust diseases of the sprouts is different from that of the adult plants. If a whole set of adult hosts can be established, the changes of the physiological subspecies may be observed. The result may be of great importance to the work of breeding rust-resistant varieties.

The study of the principle of occurrence of rust diseases also awaits further advancement. At present, the study remains a research of the rules of overwintering, oversummering, and spreading between regions. If the "final source" of the various rust microorganisms, the routes they travel, their occurrence and development may be studied over a large area and be understood more clearly, we may be better equipped to form an effective strategy in our work of breeding rust-resistant varieties. Naturally, any disclosure of the basic characteristic and mutation of the rust organisms will promote the work of breeding rust-resistant varieties.

Many agencies have established themselves as good examples in the cooperation between plant breeding work and plant pathology work, such as the research work of the Institute of Grain Crops of Shensi Branch and the Institute of Plant Protection of Chinese Academy of Agricultural Sciences. The cooperation of the two sciences is still not close enough for many other agencies, however. The important problem is to set up concrete jobs and conditions to strengthen mutual assistance so as to promote better utilization of the abilities of both.

Moreover, attention should be given not only to the rust-resistance of a variety, but also to its compound agricultural characteristics. The value of a variety is in the end measured by its function in production. A variety may have good rust-resistant characteristics, but its yield may not be high, and it certainly will not be promoted very far. For example, Anhwei 3 is the recently obtained variety in Anhwei Province. It is more rust-resistant than Pi-ma 1, but its combined yield characteristic is not so good. In an ordinary year, its yield is generally not as high as that of Pi-ma 1, and therefore, it cannot be promoted. The Kiang-su Branch of Chinese Academy of Agricultural Sciences produced two sets of materials, the first set, such as 5204 and others, is not winter hardy and is not resistant to stem rust. The second set, such as 5034 and 5042, is very late ripening, and can contact gebberellic disease easily. The latter cannot be directly utilized either. These two sets may only be used for further hybridization to obtain such varieties as Hua-tung 6 which have better combined characteristics before they are used in production.

Hence, it is necessary to consider the needs of a special locality. In the areas where the disease does not occur very frequently, or the damage is never serious, the rust-resistant requirement may be not as strict, and materials chosen for breeding purposes should conform to the special needs of a particular locality.

(2) More Studies Are Needed Concerning the Genetic Principle of Rust-Resistance and Other Characteristics:

Although some agencies have already begun to study this subject, the studies are most done on the basis of summarizing the data of the work of breeding the rust-resistant varieties. The only result thus obtained is

the strong dominance or recessiveness of a certain disease-resistant variety in the transference of this characteristic to its hybrid offspring with a variety susceptible to the disease. This result has its practical significance, of course, but it is more important to learn the different sources of disease-resistance of the different disease-resistant varieties, and the genetic relationship of the disease-resistant characteristics. This is the knowledge we need in order to prevent the varieties in production from losing their resistance, and in order to obtain this knowledge, more profound study is needed. We must not only study the relationship of the parent pairs with F_1 and F_2 generations, we must also study the performance of F_3 and F_4 inbreeding offspring and the third generation hybrids. We must not only study the pairing of a disease-resistant variety with a variety susceptible to the disease, we must also study the pairing of a disease-resistant variety with a disease-resistant variety. We must study not only the genetic principle of resistance to one physiological subspecies, but also that of resistance to many subspecies. On this subject, there are some foreign research data worthy as references, such as Briggs and co-workers' study of the black head disease, and Macer's study of the strip rust disease.

Detailed work on the genetics of rust-resistance requires good research conditions. The varieties and the strains of microorganisms must be pure, and there must be a certain level of equipment condition. At present, only a few better equipped agencies can carry out the work, but the other agencies can accumulate some data on the basis of their analysis of the parent pairs and the rust-resistance of the offspring. Of course, the genetics of other agricultural characteristics of the varieties also calls for special attention immediately.

(3) Strengthen the Work of Introducing New Varieties, Improve the Method of Breeding, and Adopt the Method of Diversified Attack:

In recent years, the Institute of Crop Breeding and Cultivation, Chinese Academy of Agricultural Sciences introduced many varieties from several countries, and made a large-scale collection of domestic varieties. This work, which has been so successful, must continue. The superior varieties in the collection should be dispatched to a few areas, especially the areas where the rust diseases occur frequently, so that their characteristics may be identified in order to select the high yield varieties that are resistant to many physiological subspecies of rust microorganisms. In order to learn the resistance of these varieties, the more reliable method is artificial inoculation, and for the purpose of learning their specific reaction to the various physiological strains, they must be examined in the greenhouse during the sprouting time, and when they become adult plants.

Regarding the method of breeding, more diversified systems must be adopted. The work of repeated hybridization that has been started should be developed further, and the experience should be timely summarized in order to accumulate data for further improvement of the work. The method of inbreeding should also be developed with greater efforts.

Judging from the history of the work of breeding rust-resistant wheat varieties, the method of inbreeding proves to be a successful and effective method. For example, the stem rust-resistant spring wheat varieties of Thatcher and Newthatch were obtained with the inbreeding method. Some time ago, we used Yen-ta 1885 as a rotated parent for hybridization, but no outstanding result was obtained. It is perhaps due to the fact that the compound agricultural characteristics of Yen-ta 1885 are not sufficiently ideal in the first place. If a relatively ideal parent can be found to serve as the rotating parent, the inbreeding method is really quite reliable. On the other hand, the dominant characteristic of the rust-resistance of the parent is also important. Recently, Peking University of Agriculture started its project of inbreeding Pi-ma 1 and Nung-ta 183 to improve their rust-resistance, but to this day, no detailed report has been published.

The inbreeding method is also useful for the preservation of the rust-resistance of a variety. In order to prevent a variety from losing its rust-resistance, Jensen once suggested the method of obtaining varieties of mixed systems. Borlaug of Mexico has also adopted a method similar to inbreeding to obtain varieties resistant to a whole set of diseases. He obtained several varieties with similar appearanc- it resistant to different physiological strains, and mixed them mechanically to form several mixed varieties. The varieties used for the mixture should vary with the physiological strains of the microorganisms. If in a certain year, some of the crop plants become infected, the slowness of the particular strain of microorganism in developing and spreading will prevent the occurrence of a catastrophic damage, and a relatively stable yield may be obtained.

[JPRS Note: Original document ends here, seems incomplete.]