ON THE GREEN REVOLUTION

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THE AUTHOR ATTEMPTS in this article to deal objectively with the so-called "green revolution" which is now making progress in developing areas, especially in food-deficient countries in the tropical and subtropical regions of Asia, and to reveal the problems involved in the revolution. The aim of this attempt is to find the key to the future of this new historical phenomenon. The order of description and discussion will be as follows: (1) to outline the "green revolution" in relation to historical facts, (2) to summarize various problems concerning the revolution as viewed by many scholars and researchers, and (3), on the basis of (1) and (2), to point out some issues which the author feels are related to the essence of the "green revolution" and express his own views concerning them.

I. OUTLINE OF THE GREEN REVOLUTION

The term "green revolution" began to be used in the United States in 1968, and in 1969 it gained worldwide currency. But the term has not yet been clearly defined. Here the author interprets it tentatively as a new trend toward increased production and agricultural development propelled by excellent new varieties or "high-yielding varieties," a trend which has been remarkable in developing areas since the latter half of the 1960s.[1]

We understand the "green revolution" as a historical phenomenon which appeared in the 1960s. Being a historical phenomenon, its roots are deep and many factors are expected to be related to it. Nevertheless, the revolution suddenly appeared before the eyes of the world's intellectuals. It was as late as 1967, in which India recovered from two successive years of very poor crops, that scholars and specialists in agriculture became aware of the first postwar change in the relation between the supply and demand for foods in developing areas. Surprisingly, in 1968, the attitude concerning foods changed decisively from pessimism to optimism, especially in the United States, and such new terms as "green revolution," "agricultural revolution," and "seed-fertilizer revolution" came into common use. Finally, in 1969, the attractive term "green revolution"

[1] The term "green revolution" was first used by William S. Gaud, Former Director of AID, in a speech in March 1968, addressed to the Society of International Development [17, p. 24]. Referring to the same trend, Lester R. Brown called it the "agricultural revolution" [5]. This new trend in developing areas has also been called the "seed-fertilizer revolution" [13, pp. 569–682].

became common on a worldwide scale. This drastic worldwide change in attitude concerning foods was exceptionally dramatic.

In the author's view, however, the green revolution as a historical phenomenon did not appear suddenly in the latter half of the 1960s simultaneously with the change in attitude concerning foods. Changes on the level of facts should be regarded as having been far more advanced than the realization of the changes. The mainstay of the green revolution is the application of modern technology, centered on high-yielding varieties, in tropical and subtropical agricultural environments. For such applications there are many prerequisites and, therefore, the long preliminary period after World War II was necessary. The revolution per se was making steady progress from around 1960 and, in the latter half of the 1960s, the speed of the revolution accelerated. This acceleration was partly due to the appearance of new rice and wheat varieties created with U.S. aid and partly due to the influence of the bad harvests, first in India and then in Pakistan, which gave rise to a worldwide sense of crisis in foods. People were not aware of new agricultural trends in Asian developing countries until 1967 or 1968 because they were distracted by the bad harvests in India and Pakistan. Another important reason was the fact that their attention was directed only to new varieties created with U.S. aid, and not to the existence of the preceding "local improved varieties."

The green revolution consists roughly of (1) the improvement of the technological and social conditions necessary for wide adoption of high-yielding varieties and (2) the creation of high-yielding varieties which are suitable for tropical and subtropical environments. In the process of the revolution to date, (1) has outdistanced (2). This is the secret of the rapid progress of the green revolution at the end of the 1960s.

The definition of high-yielding varieties has been vague. Therefore, the author tentatively defines them as such varieties which produce the same or nearly the same size harvests in tropical and subtropical areas, in which low harvests have been regarded so far as fatal, as in temperate areas. Behind the appearance of these varieties lies the rapid worldwide advance in breeding science and techniques. The decisive role in the creation of these seeds was played by the United States and, to a less degree, by other countries and international organizations. Among Asian countries, Japan's contributions in the fields of rice and wheat and Taiwan's contribution in the field of rice were great.

The creation and spread of high-yielding varieties has advanced so far in relation to water-field rice and irrigated wheat in general, and particularly in India some progress has been made in corn, barley, and miscellaneous cereals. The history of the creation and spread of high-yielding varieties of wheat in the world is longer than that of rice, because the history of the improvement of wheat varieties for developing areas goes back to 1943, when the Rockefeller Foundation started the improvement in cooperation with the Mexican government. This program has been developed, and the International Corn and Wheat Improvement Center (CIMMYT in Spanish) was founded in 1966 under the sponsorship of the Rockefeller and Ford Foundations, thus playing the central role in the

improvement of wheat varieties for developing countries. High-yielding varieties developed in improvement programs in Mexico are the Mexican wheat varieties, which provided the driving force in the wheat green revolution.

In Asian developing countries, however, the history of the creation and spread of high-yielding rice varieties is far longer than that of wheat, at least as far as local improved varieties are concerned. The improvement of Indica-type rice varieties first started in Taiwan after World War II with the improvement of native varieties. The first product was the "Taichung Native 1," developed in 1953. Ceylon developed the "H-4" in 1958, and Indonesia the "Sigadis" in 1954 and the "Syntah" in 1963. Malaysia then developed "Malinja" in 1964 and "Mahsuri" in 1965. Most of these varieties were immediately diffused in each country. On the other hand, it was in 1965 that the Mexican wheat varieties were introduced into wheat-producing India and West Pakistan. There is no report concerning the success of native improvement of wheat varieties before 1965 in Asian developing countries. However, since 1960, when the Rockefeller and Ford Foundations established the International Rice Research Institute (IRRI) in the Philippines (which is comparable to the International Corn and Wheat Improvement Center), the improvement of rice varieties entered full scale development, and the wide use of high-yielding rice varieties began after 1967, when the "IR-8" (the so-called "miracle rice") developed in 1966 by the Institute gained recognition. Therefore, from the viewpoint of the improvement and diffusion of new varieties in which the United States dealt directly, wheat preceded rice in Asia, too. But considering the existence of local improved varieties, we wish to take the converse as true. Quite contrary to the early stages of the green revolution in Asia, the speed of the spread of high-yielding wheat varieties, mainly in India and Pakistan, was faster than rice in the following period.

The biological characteristics of high-yielding varieties are, in brief, (1) short, stiff stems, (2) slender, erect leaves, (3) early maturity, and (4) no photoperiod sensitivity in the case of rice. High-yielding varieties were created with consideration for these characteristics as important elements in breeding. This means that the fruits of Japanese agricultural science and technology have been fully utilized. In breeding the Mexican wheat varieties, Japanese "Nōrin 10" (developed in 1935) was widely used as breeding stock. After 1958, Japanese technical experts extended cooperation in improving local varieties of rice in Malaysia.[2] Japanese agricultural science and technology made a considerable contribution to breeding activities at IRRI and some scientists took part in experiments and studies. Furthermore, the native Taiwan varieties which were most utilized as breeding stock at IRRI were those which had been selected out by Japanese agricultural scientists during the period of Japanese rule. This does not mean, however, that we do not appreciate the efforts of agricultural scientists in Taiwan.

The next problem in the green revolution is the arrangement of the various conditions indispensable for cultivating such varieties. By these conditions, we mean the modern agricultural technology, various types of capital resources, and

[2] Concerning the breeding activities of Japanese technical experts in Malaysia, see [6].

agricultural organizations. These may be listed as follows:

(1) The infrastructure, including irrigation and drainage facilities, and the related technology; (2) modern inputs including fertilizers, agricultural chemicals, and agricultural machinery, and the related technology; (3) modern technology for cultivation and knowledge for farm management; (4) administrative and farmers' organizations which are able to popularize high-yielding varieties as well as to provide the above-mentioned capital resources and technology; and (5) facilities, techniques, and organization for drying, storing, transporting, and processing.

All of these are deficient in today's developing countries, although some of these prerequisites have been accumulated to a certain degree, though meagerly, during the twenty years after World War II through self-help efforts and aid from abroad. With these supplies, the high-yielding varieties triggered the "revolution" and, consequently, excellent progress was made possible in the 1960s. This course of events provides a clue to the near future of the green revolution. That is, when these supplies run out, the speed of the development of the revolution will fall off.[3]

Next, let us glance at the degree of the diffusion of high-yielding varieties in Asia as estimated by the U.S. Department of Agriculture. Tables I and II reveal that the diffusion accelerated around the end of the 1960s. The difference between the two tables is that the former includes corn and sorghum in addition to rice and wheat, and, what is more important, it includes local improved varieties (presumably after 1966). As a result, the degree of diffusion in Table I appears greater than that in Table II. For this reason, those who want to exaggerate the development of the green revolution prefer to cite this table.

TABLE I
ESTIMATED ACREAGE IN NEW HIGH-YIELDING VARIETIES IN ASIA

Crop year	Acres
1964–65	200
1965–66	37,000
1966–67	4,800,000
1967–68	20,000,000
1968–69 (goal)	34,000,000

Source: [7].
Note: Includes rice, wheat, corn, and sorghum; and also local improved varieties.

Tables III and IV show the diffusion of high-yielding varieties of rice and wheat in the 1968–69 crop year by country. First, it is noteworthy that, in all Asia, the acreage planted with high-yielding varieties of wheat as a percentage

[3] There are two phenomena which mitigate this fear. One is the recent rapid spread of small-scale irrigation facilities, mainly in India and Pakistan, and other is the introduction of the "packet idea." High evaluation of these developments will make people optimistic concerning the future of the revolution.

TABLE II

ESTIMATED AREA PLANTED TO NEW HIGH-YIELDING VARIETIES OF WHEAT AND RICE IN THE LESS-DEVELOPED NATIONS

In acres (round)

Crop year	Wheat[a]	Rice[b]	Total
1964–65	[c]	[c]	[c]
1965–66	23,000	14,000	37,000
1966–67	1,554,000	2,343,000	3,897,000
1967–68	9,558,000	6,762,000	16,420,000
1968–69	14,750,000	12,300,000	27,050,000

Source: [8].

[a] Essentially all Mexican or Mexican-type varieties. Excludes Mexico.

[b] Primarily IRRI varieties, but also includes ADT-27 and Taichung Native 1 in India, and BPI-76 in the Philippines. Does not include local improved varieties in Ceylon and Taiwan.

[c] Negligible.

TABLE III

ESTIMATED ACREAGE OF NEW RICE VARIETIES IN SOUTH AND SOUTHEAST ASIA (1968–69)

(Thousands of acres)

	Total Rice Crop Area	Planted to New Varieties	Percentage of Total Area
Burma	12,297	470	4
Ceylon	1,637	17	1
India	91,344	6,500	7
Indonesia	20,950	416	2
Laos	1,550	4	—
Malaysia (West)	1,182	225	19
Nepal	—	105	—
Pakistan (East)	21,212	300	1
Pakistan (West)	3,743	761	20
Philippines	7,904	2,592	33
Vietnam (South)	5,528	109	2
Total	167,347	11,499	7

Source: [3].

Note: Principally IRRI varieties, plus ADT-27 and Taichung Native 1 in India, Mahsuri in Malaysia, and C4-63 in the Philippines and Indonesia.

of total wheat acreage is 21 per cent, while the percentage of high-yielding varieties is a low 7 per cent in the case of rice. The rate of diffusion of high-yielding rice varieties is highest in the Philippines, followed by West Pakistan, West Malaysia, and India. The problem here is Ceylon. In Ceylon, new varieties are almost entirely limited to such local varieties as "H-4" and "H-8." Therefore, if these varieties are regarded as high-yielding varieties, the acreage planted with high-yielding varieties is as high as 85 per cent.[4] However, in Table III

[4] Actual results for the 1967–68 crop year based on data submitted to the Ninth FAO Regional Conference for Asia and the Far East, Bangkok, November 1968.

TABLE IV
ESTIMATE OF ACREAGE OF NEW WHEAT VARIETIES IN ASIA (1968-69)
(Thousands of acres)

	Total Wheat Crop Area	Planted to New Varieties	Percentage of Total Area
Afghanistan	5,500	300	5
India	39,432	10,000	25
Iran	4,925	25	1
Lebanon	151	1	—
Nepal	371	133	36
Pakistan	14,977	6,020	40
Turkey	20,015	1,780	9
Total	85,371	18,259	21

Source: [8].

the percentage given is only 1 per cent since these varieties are excluded. On the other hand, in West Malaysia, since local improved "Mahsuri" is included as a high-yielding variety, the percentage of acreage planted with high-yielding varieties of rice is high. In the case of wheat, the major countries which succeeded in spreading new varieties are India, Pakistan, and Turkey. The rate of diffusion is highest in Pakistan, followed by Nepal, India, and Turkey.

Finally, the author wishes to point out the strong influence of the American viewpoint on facts and ideas concerning the green revolution. The greatest driving force in the green revolution is U.S. aid and behind the revolution lies a characteristically American viewpoint. It was the Americans who first "discovered" the phenomenon, gave a name to it, propagated it, and conducted research and studies of it. Of course, we must highly evaluate the American contributions to the green revolution, but at the same time we must guard against the biases in the recognition and evaluation of, and measures for the revolution which arise from this American viewpoint.

II. THREE STAGES IN THE BREAKTHROUGH AND RELATED PROBLEMS

Let us divide the stages of the green revolution into (1) the technological breakthrough, (2) the production breakthrough, and (3) the agricultural breakthrough, and examine the problems pointed out so far by various scholars.[5]

A. *The Technological Breakthrough*

The problem in this stage is whether or not it is technically possible to adopt new technology centered on high-yielding varieties not only on the level of experimentation but also on the farming level. Naturally, the adoption of new technology causes changes in the socio-economic conditions surrounding farms and

[5] These terms for the stages are those of Lester R. Brown. However, Brown has not defined these terms. Therefore, the present author has used these terms according to his own definition [4].

farmers per se. These changes, however, should be limited to those which seem to be possible when viewed from the reality of the developing countries.

Optimists now commonly hold that a technological breakthrough in the above-mentioned sense has succeeded in the 1960s to a considerable extent in the case of rice and wheat. The greatest factors contributing to this are the success in creating high-yielding varieties and the easy availability to farmers of such inputs as fertilizers, agricultural chemicals, agricultural machinery, etc., which are necessary for cropping these varieties, through the self-help efforts of developing countries and foreign aid. The second factor which contributed to this success is the easy acquisition to water which is essential for growing high-yielding varieties, partly because large-scale irrigation facilities gradually began to bear fruit and partly because small-scale irrigation by means of tube-wells and low-lift pumps has begun to spread rapidly. The third factor is that the technology necessary for cropping high-yielding varieties has been readily available to farmers whose intellectual level is low, due to the development of extension services and the appearance of the packet idea.[6]

However, it should be pointed out that many problems remain unsolved at this stage. First, the high-yielding varieties so far created do not suit consumer tastes because of their flavor, form, and quality. Second, new varieties are susceptible to damage by pests and diseases. Especially when varieties of the same kind are cultivated simultaneously in large areas, this problem will inevitably be serious. Third, the cropping pattern and the operational harvesting and processing system have not been established to meet the requirements of multiple cropping made possible by the introduction of high-yielding varieties.

B. *The Production Breakthrough*

The task at this stage is to spread the new technology which it has become possible to adopt on the farm level as widely and rapidly as possible in order to attain the target for the increase of the production of foods. At this stage, the consolidation of various socio-economic conditions necessary for the continuing adoption of new technolgy is the key to success. Therefore, many problems must be solved at this stage.

The first problem is the efficiency and continuity of the development and diffusion of new technology. The factors for solving this problem will be aid from advanced countries and the establishment of organizations through self-help efforts on the side of developing countries. At present, in many cases, stress has been laid on the former. For example, Lester R. Brown attaches importance to (1) the function of a global network for the transfer of experimental results and technology which was organized mainly by the Ford and Rockefeller Foundations; and (2) activities of "multinational agribusiness corporations" engaging in the production and distribution of such inputs as fertilizers, agricultural chemicals, agricultural machinery, and so on (see [4, pp. 47–65]).

[6] This refers to the method of delivering a packet which contains a certain amount of seeds and other necessary inputs including fertilizers, agricultural chemicals, etc. [4, p. 72].

The second problem is the profit relation between inputs and outputs when new technology is adopted. There are two kinds of profit in this case: one from the farmer's viewpoint and the other from that of the national economy. The former is advantageous because of assistance from both the home government and foreign organizations. However, since the spread of new technology will decrease the amount of assistance per farmer and an increase in production will reduce the price of foods, there are problems to be solved. To the latter should be added social costs and profits.

The third problem is the financial system which is essential for spreading new technology among farmers.

The fourth problem is the incomplete marketing system. This problem is a difficult one because the green revolution is now making progress in food-importing countries with an incomplete marketing system.

The fifth problem is the relation between new technology and economy of scale. There are two opinions concerning this problem: one holds that since the new technology for the green revolution is neutral to scale, it has little relation to farm size (see [4, pp. 113–114] and [13]); and the other maintains that the economy of scale functions because the green revolution needs new inputs, especially agricultural machinery, and bears risks.[7]

The sixth problem is the relation between new technology and the land system. More concretely, the problem is whether it is easier to spread new technology rapidly under the owner-farmer system or under the large landowner system (which includes both direct management of farmland by landlords and the tenant system). If technology spreads more easily under the owner-farmer system, then land reform will be essential. On the other hand, under the large landowner system, land reform will be a factor impeding the spread of new technology. In the first case, importance is attached to incentives to farmers and, in the second case, to the economy of scale. The former argument has prevailed so far, but recently the role of landlords has begun to be reevaluated.[8]

C. *The Agricultural Breakthrough*

After success in spreading new technology on the farm level and increasing production, the important task at this stage is how to maintain increasing production for a longer period and how to link it with the development of agriculture on the whole and further with the development of the national economy. There are many problems at this stage to be solved on the high policy level.

The first to be mentioned is the securing of sales markets for increased supplies of foods and the necessity of diversification in agricultural production. Since the green revolution is making progress in food-deficient countries, there will be no problems until self-sufficiency in food supply is attained, when the securing of sales markets will become a serious problem. If this problem resists solution,

[7] The majority hold this view. In many cases, it is a generalization from the process of the green revolution to date and not the result of scientific analysis.

[8] For example, FAO evaluates highly the large landowner system in India, West Pakistan, and the Philippines in the spread of high-yielding varieties [9, pp. 82–83].

it will be necessary to diversify agricultural production.

The second problem is how to cope with the social tension and instability which is expected to arise from the diffusion of new technology. Since new technology spreads first to the more privileged farmers and landowners in rich areas, opposition is expected to arise in the process of the diffusion of new technology (1) between rich farmers and poor farmers, (2) among landlords, tenant farmers, and agricultural workers, and (3) between rich and poor areas. When the increase in food production lowers the price of food, not only the above opposition will be intensified but also contradictions will arise (4) between farmers and urban consumers, as well as (5) between farmers and those engaged in agribusiness. On the other hand, when the spread of new technology causes the flow of surplus rural labor force into cities, class antagonism will be intensified (6) between the poor and the rich in cities. High-level policy measures are necessary for solving these oppositions and the social instability caused by them. What is to be noted here is the fact that pessimistic scholars and researchers who lay stress on the above-mentioned oppositions and instability tend to emphasize that the economy of scale applies to the new technology.

The third problem is the employment policy for the rural labor force. The necessity of such policy will differ according to whether the adoption of new technology is regarded as creating new employment opportunity through labor-intensive cultivation and multiple cropping or whether the mechanization of agriculture based on new technology is looked upon as removing the existing labor force. Even though the former is accepted, there will naturally arise a surplus labor force if the newly-created employment opportunity is not enough to absorb the exploding rural population. In any case, social instability will be intensified if the surplus population accumulated in rural villages begins to flow into cities.

The last problem is the necessity of realizing balanced growth in agriculture and industry. Industrialization is necessary for (1) providing a market for developing agriculture, (2) providing employment opportunity for the surplus labor force in rural villages, and (3) producing the inputs necessary for agriculture.

III. BASIC CONTROVERSIES CONCERNING THE GREEN REVOLUTION

The author wishes to express his own views concerning the following four points on the basis of his understanding of the green revolution outlined above and according to the problems pointed out by many scholars.

The first and most important point is the biases deriving from the American viewpoint in the recognition and evaluation of, and measures for, the revolution. If these biases are modified, the image of and measures for the green revolution will be different. The first bias exists in the vague and arbitrary definition of high-yielding varieties. The Mexican dwarf wheats and varieties created at the IRRI are properly defined as high-yielding varieties. But a bias exists in the selection of local improved varieties as high-yielding varieties. American scholars

generally regard the 1965–66 crop year as the starting year of the spread of high-yielding varieties. This is because in that year Mexican wheat varieties were first introduced into India and Pakistan and the "Taichung Native 1," which has been recommended by the IRRI, was transplanted in India via the IRRI. Consequently, the "Taichung Native 1" was ranked as the first high-yielding variety of rice, though this variety itself is a local improved variety created in Taiwan. In regard to rice, high-yielding varieties are defined as those of "medium to short stature" which were introduced into tropical areas after the 1965–66 crop year ([2, p. 1]). Thus, such famous local improved varieties as "H-4" and "H-8" of Ceylon and "Malinja" of Malaysia are not included as high-yielding varieties. Curiously enough, however, Indian "ADT-27" (which began to spread in 1964–65) is included among high-yielding varieties. It is further noteworthy that, even though the high-yielding varieties have been thus defined, the above-mentioned "H-4" and others are included among high-yielding varieties when it is necessary to exaggerate the fruits of the green revolution. Here appears the arbitrariness and opportunism in the definition of high-yielding varieties. (Cf., Table I.)

We wish to insist that local improved varieties be included as far as possible among high-yielding varieties.[9] In doing so, the period in which the use of high-yielding varieties began to spread (or the period in which the green revolution started) would be around 1960, not the 1965–66 crop year. The above-mentioned American bias makes it most difficult to deal with the case of Ceylon. In Ceylon, the yield of rice per acre began to increase from the end of the 1950s, and by the latter half of the 1960s rice cultivation reached the stage of a "yield take-off." This is due to the wide use of local improved varities, including "H-4." (The rate of spread of local improved varieties was 85 per cent in fiscal 1967–68.) On the contrary, the rate of spread of such high-yielding varieties as defined by Americans was only 1 per cent, as shown in Table III. FAO, which adopts the American definition, could not explain exactly the events in Ceylon ([9, pp. 83–84]). The same is true of Malaysia in the early 1960s.

The second outstanding bias is seen in the over-evaluation of the contributions made by Americans and the neglect of factors innate in Asian countries, especially their nationalism. The author believes that the American contribution has been exaggerated in proportion to the neglect of the fruits of self-help efforts in Asian countries. The sources for this exaggeration are three. First, the neglect of local improved varieties gives an unreasonably strong impression that the green revolution suddenly materialized immediately after the United States became active in spreading new varieties. The second is the neglect of both the self-help efforts and the strong nationalism behind them which were particularly intensified in Asian developing countries after the United States began promoting the diffusion

[9] FAO concludes: "a local improved variety of rice demands an intermediate level of technology requiring less cost, less risk, and less labour discipline than the new high-yielding varieties" [9, pp. 83–84]. But since there are local improved varieties which are little different from the new high-yielding varieties, such a generalized conclusion is of doubtful validity.

of new varieties. The diffusion of high-yielding varieties and breeding activities in many Asian developing countries clearly became active in the latter half of the 1960s. This is, however, not solely because of U.S. aid or the provision of excellent breeding materials by IRRI and CIMMYT. Thirdly, the contributions made by Japan and Taiwan, which stand outside of the green revolution, have not been properly evaluated.[10] We have already referred to the Japanese contribution in the previous section. Taiwan created "Taichung Native 1" and has been producing many excellent breeding stocks including "Deo-geo-woo-gen." ("Taichung Native 1" was used as the breeding stock in the creation of "IR-20.")

The third bias is seen in the excessive stress laid on exogenous factors concerning the continuity of the production breakthrough and the neglect of the need of self-help efforts of developing countries. (This is related to our third point.) The fourth bias is a strong tendency to deal with rice and wheat as one problem area and not to distinguish between them.[11] This is related to our second point.

We insist, as the second point, that rice and wheat should be distinguished. The necessity of the green revolution, the time of its appearance, the main organizations which have promoted it, and its historical meaning are the same for both rice and wheat, so that rice and wheat constitute the two major parts of one historical phenomenon. However, rice and wheat are crops of a different nature and rice cultivating areas are quite different from wheat cultivating areas in natural, social, and historical conditions. Therefore, unless we first distinguish between them, all discussion will be confusing and fruitless.

In the author's view, new technology will be more closely related to the economy of scale in wheat cultivation, so that wheat cultivation is suitable for mechanization and advantageous in cases of large-scale land holding (or, in other words, landlords will play a great role). At the same time, however, mechanization tends to lead to labor-saving and the emergence of surplus labor force. The new technology for rice cultivation is in marked contrast in every point to that for wheat. That is to say, the green revolution in wheat cultivation will follow the path of advanced wheat-cultivating countries, while that in rice cultivation will follow the path of advanced rice cultivating countries such as Japan and Taiwan.

The third point is the problem of the continuity of the green revolution. In regard to this continuity, we wish to focus our attention on the following two points: the continuity of the development and diffusion of new technology at the stage of production breakthrough and the possibility of overcoming the social unrest which is likely to follow the production breakthrough.

As mentioned above, the factors which are expected to produce the continuous development and diffusion of new technology are a global network for the transfer of experimental results and technology which is provided mainly by private

[10] For example, Brown refers only to the contribution of Japanese "Nōrin 10" to the breeding of Mexican wheat varieties, and not to Japan's greater contribution in the field of rice cultivation [4].

[11] This may be a bias common to non-rice cultivating countries.

foundations, and the activities of multinational agribusiness corporations, both of which are exogenous factors. In addition, the low-level knowledge of farmers is taken to be easily overcome by means of the packet idea.

However, the above way of thinking depends too heavily on exogenous factors and is too optimistic. In this case, continuity in its real sense seems to be attained only when developing countries have the ability to create and spread new varieties on their own, as has been the case of Taiwan. For this purpose, it is hoped as a precondition that the farmers will be enlightened enough to employ the new technology so that there will be no need for such an easy means as the packet idea. Unless developing countries develop to the above-mentioned extent, the green revolution cannot but be regarded as a temporary phenomenon which will disappear as soon as foreign aid is cut off for some reason.

Next, let us discuss whether or not the social unrest caused by a production breakthrough can be overcome. Pessimistic observers tend to stress social unrest too much, with which the present author cannot agree. It cannot be denied that, at the initial stage of the green revolution, such social unrest indicated above will develop and possibly lead to political instability. But it does not seem that such unrest can put an end to the green revolution. Rather, I prefer to emphasize the active aspects of social unrest because I think that this has been the normal course of all technological innovation, and if necessary measures are taken it will serve as a springboard. In this regard, the reader should recall the example of the diffusion of "Ponlai" rice in Taiwan.

However, the situation may be different in the cases of rice and wheat. One of the reasons why we must distinguish between rice and wheat is the fact that the danger of breeding social unrest is greater in the case of wheat than in the case of rice.

Our last point is the relation of the green revolution to theories of economic development. As in general discussions of the green revolution, theory has merely followed reality in an *ex post facto* manner. The green revolution is not a phenomenon which has arisen from the application of any particular theory to reality. On the contrary, up to the present people have tried only to follow and theorize on reality from the viewpoint of existing theories, and they have discussed only the implications of the green revolution in the context of economic development theories.

Those who have promoted the green revolution so far are mainly groups of scientists and technical experts in agriculture. And they have adopted what may be called a technological approach, placing emphasis on practice. Since this approach succeeded to a certain degree at the initial stage, there developed a certain amount of optimism, as seen in the stress laid on the effects of new technology in inducing social and economic development.[12] Optimists hold that since new technology will not be useful unless it is applied as a package, strong efforts toward eliminating the barrier will arise when the diffusion of high-yielding varieties faces the barrier of the lack of various factors for supplementing the

[12] Gunnar Myrdal calls this "technocratic euphoria" [14, p. 130].

diffusion, and advances in the modernization of production techniques will easily change farmers' traditional attitudes, way of living, and various related systems, and give rise to the possibility of land reform.[13] This way of thinking is very similar to the development theory based on unbalanced growth which Albert O. Hirschman argues for in [10], and the intimate relation between them often becomes a topic of discussion [17]. However, this does not mean that the Hirschman theory has been intentionally applied in the agricultural field.

The green revolution seeks to rapidly modernize traditional agriculture by introducing among subsistence farmers in developing countries a set of modern inputs including high-yielding varieties and modern technology. In this case, economically speaking, the relation between the cost and profits of modern inputs will be a key factor in determining success or failure. As a strategy for overcoming this problem, emphasis should be laid on research in and the development of modern inputs, the effective spread of these inputs among farmers, and the education and training for farmers who adopt them. This problem is similar to that which Theodore W. Schultz has discussed in [16] and the possibility of the application of his theory to the green revolution has often been discussed.[14] In addition, there are also arguments regarding the risks and uncertainty in the adoption of new technology, which have not been developed enough in his studies [18].

The above arguments are based on an economic approach which regards economically rational activities of farmers as a decisive factor. On the other hand, there are arguments from the standpoint of the institutional approach, which is represented by Gunnar Myrdal ([14] and [15]). In this argument, the modernization of agriculture should ideally be a gradual process starting gradually first with institutional reform, especially land reform. Therefore, people who adopt this viewpoint are generally critical of the green revolution.

To summarize the relationship between the green revolution and economic development theories, theory lags behind practice and much effort has been focused on how to interpret the facts compatibly with theory. This is due to the fact that the green revolution is in the initial stage. Therefore, in order to develop the green revolution steadily in the future, it is necessary to construct theories ahead of practice and provide effective strategies for development as soon as possible. This will start, as I have emphasized previously, after the elimination of the American biases and after the true nature of the green revolution is understood.

[13] This way of thinking is seen, for example, in [17, pp. 51ff.] and [1].

[14] In Japan, the group centered around Shigeru Ishikawa placed special emphasis on this point. Admitting partly the possibility of applying the theory of Schultz to the green revolution, and supplementing this theory, Ishikawa advocates further wide-range development strategies which lay stress on traditional inputs ([11] and [12]).

IV. CONCLUSION

The author has attempted in this article to understand the true nature of the green revolution as a great historical phenomenon which appeared in the postwar years in Asian developing countries. The author feels that the most essential requirement in doing so is the elimination of the American biases concerning the green revolution. The points which have been made from this point of view are as follows:

(1) Emphasis should be placed on the significance of local improved varieties to which people have paid little attention.

(2) If the local improved varieties are highly evaluated, it will become clear that the green revolution did not break out suddenly in the latter half of the 1960s, but around 1960.

(3) Rice cultivation and wheat cultivation, and the policies for each, should be distinguished in discussions.

(4) True continuity in the green revolution will be attained not by excessive dependence on exogenous factors, but only by continuing self-help efforts.

New development theories and strategies must be established on the basis of these points. In doing so, the author wishes to put special emphasis on the necessity of such enthusiastic self-help efforts on the part of developing countries as were seen in the creation of local improvement of varieties.

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