Historical Pattern of Development of Rice Varieties in Japan*

by

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I Introduction

Japan is one of the most notable examples of rapid general economic development and of sustained agricutural growth as well. The rice production, which holds a dominant share of the total domestic farm output in Japan, has been increased by 140 percent during the last eighty years between 1874-1833 and 1954-1963. The expansion of rice production was achieved through increase in yield per hactre, which was attributed to improved seeds and intensive application of commercial fertilizers, as

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We wish to express our appreciation to Y. Masui, J. Yamaguchi and K. Kawano, Agricultural Department of Hokkaido University, who helped to design the questionnaire.

you well know. A close relationship between the two inputs is the primary interest of us at this discussion.

Present paper is going to discuss (1) historical pattern of development of new varieties in terms of fertilizer responsiveness, (2) interrelationship between high-response-to-fertilizer varieties and supply condition of fertilizer, (3) economic incentives of farmers to adopting new varieties with particular reference to the tenancy system of Japan, and (4) some implications for agricultural development in underdeveloped countries. The underlying hypothesis is that the low-response-to fertilizer varieties may be more reasonably chosen than high-response-to-fertiltzer varieties by farmers under a circumstance of high cost of fertilizer input. As cheaper source of supply of fertilizer is made available, high-response-to-fertilizer varieties may be profitably chosen by the farmers.

The Japanese experience indicates that new varieties of rice has been developed by stages in its own way in response to local conditions and needs. At the earlier stages, effort was made to develop every kinds of varieties which did not require much of expensive commercial fertilizer. Early development of rice yield was brought about by such kind of varieties. It is only in the later period to find high-response varieties, which are associated with by cheaper source of fertilizer supply.

A certain type of tenancy system can stifle incentives of farmers to adopting new varieties. Fortunately, the fixed rent contract which has been prevailing in Japan has not caused any serious impediment in the course concerned.

New inputs in the forms of high-response varieties have been rapidly made available in underdeveloped countries, and it is widely assumed that better high-response varieties play a crucial role for agricultural development in these countries. However, the successful adoption of such varieties appears to be dependent upon the availability of certain vital inputs such as fertilizer and irrigation. Better high-response varieties by themselves are not a panacea for the production ills of underdeveloped

countries, but demand other inputs such as water control, weed control as well as cheap source of fertilizer supply.

If such varieties are not accompanied by high levels of fertilizer, pesticides, and irrigation, there is a possibility that farm income may decrease instead of increasing.

II Analytical Framework

It is commoly recognized that most of new inputs usually has to be associated with by others. For example, a higher yielding and high-fertilizer-response variety demands other inputs such as water control, weed control, insect control, pest control, application technique of fertilizer as well as more fertilizer. However, for simplicity let us assume that only the level of fertilizer input is different by varieties. Thus, given the fertilizer responsiveness, choice of variety is governed by net return of varieties, that is, a difference between gross return of rice and cost of fertilizer in terms of rice. The net return may be changed with change in the real price of fertilizer. Then it will follow that the choice of variety is governed by the real price of fertiltzer.

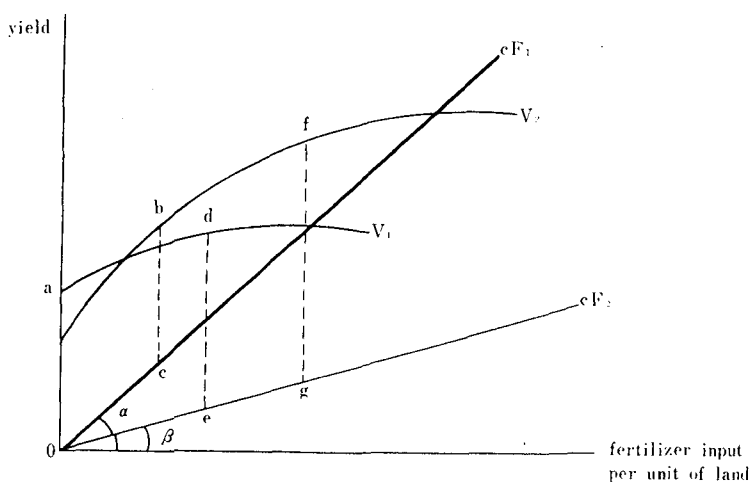

Fig. 1 Choice of variety

Let us illustrrate the point in a graphic version. Ordinate of the diagram on Fig.1 measures yield of rice and abscissa measures level of fertilizer input per unit of land area. Curve V_1 represents a typical low-fertilizer-response variety. Curve V_2 represents a typical high-fertilizer-response variety. For a rigorous treatment of the analysis, it is well assumed that the ordinate of the diagram measures the yield net of cost of complemental inputs other than fertilizer in employing the varieties. Choice of variety is governed by real cost of fertilizer in this model.

The cost conditions are indicated by up-sloped straight lines which start at the origin of the diagram on Fig.1. Line CF_1 on Fig.1. represents the cost condition of fertilizer at a level of real price indicated by tangent α. Line CF_2 represents the other condition of fertilizer cost at another level of real price indicated by tangent β. At higher price of fertilizer, variety V_1 brings about net return of oa on the diagram, and variety V_2 brings about net return of bc. Then variety V_1 is more profitable one under the cost condition of fertilizer indicated by line CF_1 than variety V_2. At lower price of fertilizer, the opposite is true. Variety V_2 is more profitable one than variety V_1. It will be easily seen that there is a critical level of the real price of fertilizer which dictates profitability of two varieties. The critical level is indicated by the slope of common tangency to both curves V_1 and V_2. At that level of real price, two varieties are indifferent. At the higher price of fertilizer than the critical level, variety V_1 may be chosen by farmer, and at the lower price, variety V_2 may be chosen. If a consideration on the cost of application of all inputs other than fertilizer in introducing each variety should be paid, more elavorated discussion would be in order. But, for the purpose of present paper, it is suffice to see that choice of variety is governed by real price of fertilizer.

Historically speaking, in the earlier period when availability of fertilizer is limited and its real price is high, the low-fertilizer-response varieties tends to be prefered in farmer's choice of varieties and in research

and development of varieties as well. In other words, upward shifts of yield curve in parallel with curve V_1 on the diagram may be prevailing in the earlier period. In the later period when the availability and the real price of fertilizer are improved favorably for farmers, high-fertilizer-response varieties tend to be prefered in farmer's choice and research and development of varieties. In this case the upward shifts of yield curve may be accompanied by increasing slope, which means increasing marginal productivity of fertilizer input.

III Relationship between real pice of fertilizer and varietal responpse

We are going to analyse the relationship between real price of fertilizer and varietal response on the data of the experiment stations in Aomori district and Hokkaido district. Although the data come from limited regions, they may well illustrate the interdependency between high-response-to-fertilizer varieties and supply conditions of fertilizer. The historical pattern of development of new varieties in terms of fertilizer responsiveness is divided into two stages. Saigara and Kamenoo in Aomori, Akage, Bozu, Bozu-6 and Eiko in Hokkaido are varieties which belong to stage I. On the other hand, Rikuu-132, Norin-1 and Fujisaka-5 in Aomori, Fukoku and Mimasari in Hokkaido are varieties belonging to stage II. As indicated on Fig. 4 and Fig. 5, the varieties of stage I are less responsive to nitrogen, and the varieties of stage II are highly responsive to nitrogen.

How is such difference in fertilizer responsiveness of varieties between stage I and stage II connected with decline of real price of commercial fertilizer which is indicative of development of the fertilizer industry? The real price of commercial fertilizer, as indicated on Fig. 6, declined remarkably over the period of 1883-1962 except 1943-1947. Although the real price of commercial fertilizer declined remarkably, farmers in Aomori and Hokkaido chose the low-response varieties up to around 1930. The real price of fertilizer was still too high for farmers to choose profitably the high-response-to-fertilizer varieties in the period prior to around 1930 in either district.

Up to that period effort had been made to develop better low-response-to-fertilizer varieties. As the relative price of fertilizer become lower enough, the high-response-to-fertilizer varieties were developed and chosen profitably after 1930's. It should be noted that in the period of 1943–1947 when the real price of fertilizer rose sharply, Rikuu-132 of low-response type of variety of stage I was substituted for Norin-1 of high-response type in Aomori, and Eiko for Fukoku in Hokkaido.

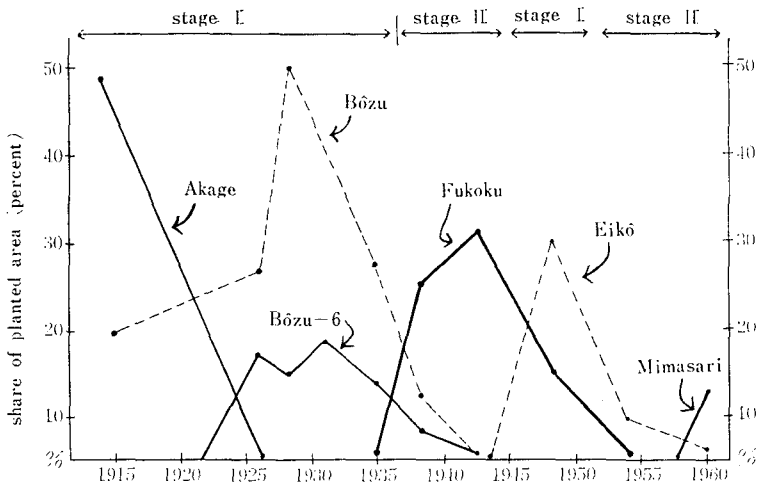

Fig. 2 Changes of dominant varieties in Hokkaido (Kamikawa)

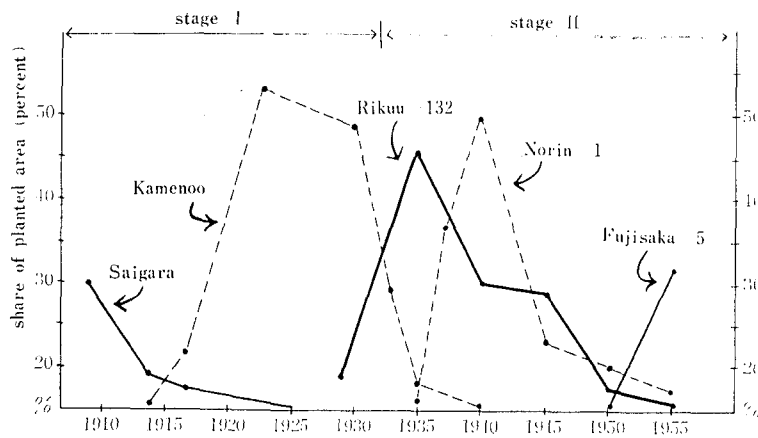

Fig. 3 Changes of dominant varieties in Aomori

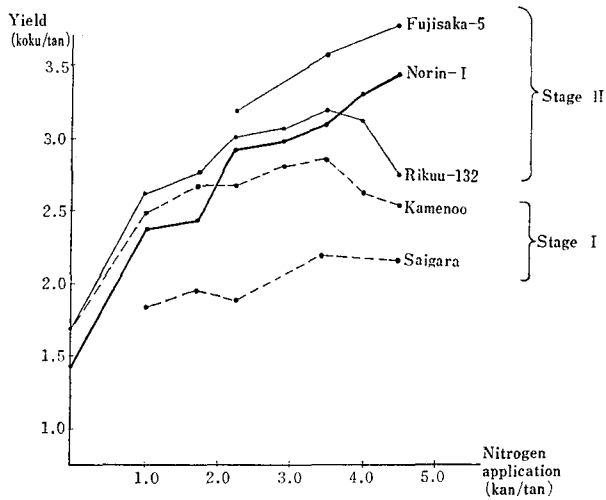

Fig. 4 Varietal Response to Nitrogen in Aomori

Source: Nôgyô Siken Seisekisho (The reports on agricultural experiments at the experiment station in Aomori) 1900-1905, 1927-1932, 1950-1955

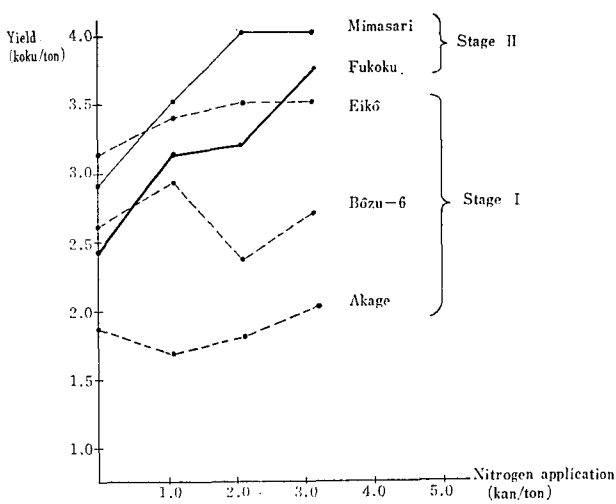

Fig. 5 Varietal Response to Nitrogen in Hokkaido (Kamikawa)

Source: A.Tanaka, T.Yamaguchi, Y. Simazaki and K.Sibata, "Hokkaido ni okeru Suito Hinshu no Keisitu Hensen ni kansuru Eiyô Seirigakuteki Kousatu" Jour. Sci Soil. and Manure, Japan Vol.39

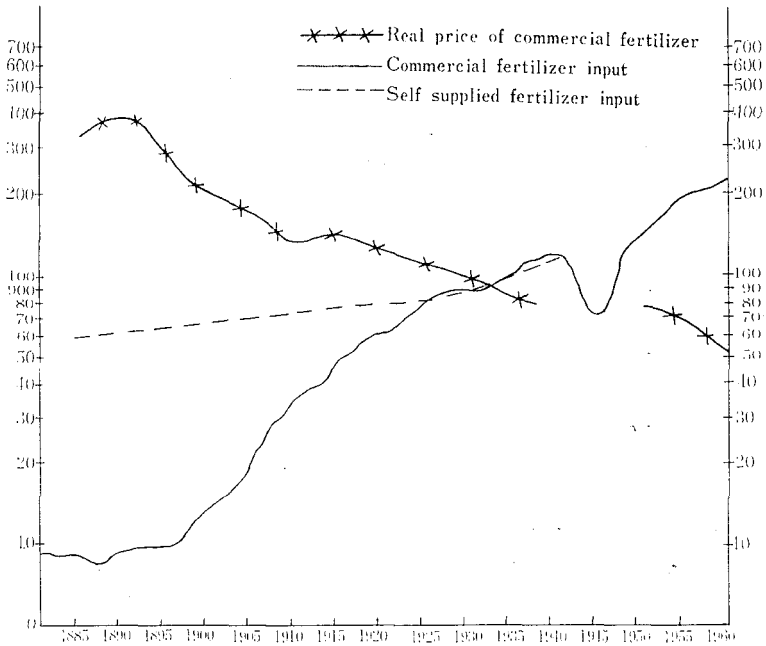

Fig. 6 Changes in fertilizer inputs and commercial fertilizer price (inputs in terms of the index of input per unit land area, 1933-1936=100, price in terms of the fertilizer price index deflated by the rice price index, 1933-1936=100) Source : Y.Hayami, "Demand for Fertilizer in the Course of Japanese Agricultural Development" Jour. Farm Econ., Vol.46 No.4 Nov.1964

IV Role of landlord in the adoption of new varieties

Though there are many cultural, institutional and economic factors in adoping new varieties, we concentrate our discussion on the function of land tenancy system in this section. It is commonly held that the traditional landlord system tends to impede technological progress in agriculture. My concern, here, is to examine whether the landlord system really impeded adoption of new rice varieties at the earlier stages of development in Japan.

Fig. 7 shows that yield of rice was rising steadily in spite of nigerdly availability of commercial fertilizers for the period of 1878-1900. In the period, any local agricutural experiment stations had not been set

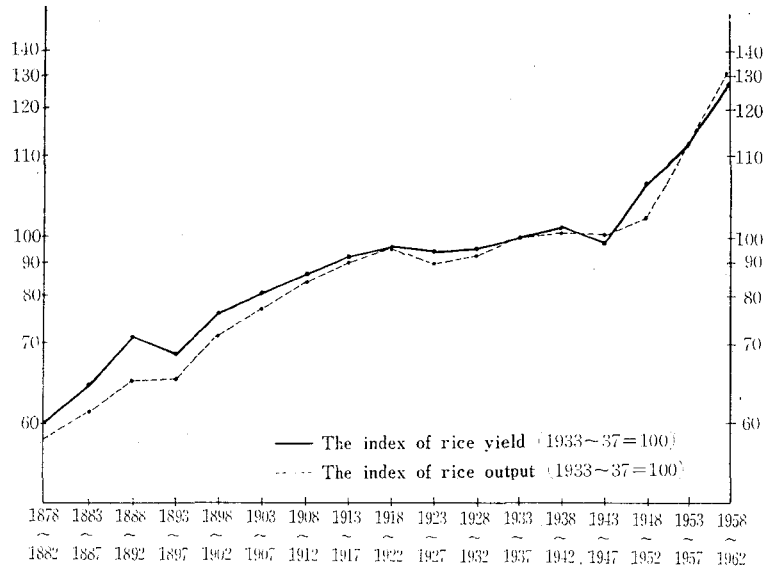

Fig. 7 Changes in rice output and yield in Japan

up yet, and there was no high yield varieties which was developed by the agricultural experiment station. What is the contributing factor to the successful performance of the rice yield in this period? Most of new varieties were produced by selection method on existing varieties in this period. Leader farmers and landlords played the greater parts in this works. They held many variety exhibitions and yield contests, and made good use of them in every opportunities to find better varieties and exchange them among different localities where they come from. The exchange of better varieties were the most important achievement which were carried out by local landlords in the earlier period.

Most of the landlords resided on farms and cultivated a part of their lands themselves in the period. It is natural consequence to find the landlords eager in multiplying the better varieties to disseminate them to their tennants.

There were sufficient incentives for the tennants to respond to the better varieties since most of the recommended varieties were such kind

that they did not require any significant amount of expensive fertilizer in the period, and prevailing rent payment system was based on fixed-rent contract so that returns from the better varieties were accrued to the tennants.

At the turn of the last century, newly born local agricultural experiment stations started developing better varieties through breeding method. Importation of soybeen-residua was increased also around that period to lead to improved supply conditions of commercial fertilizer favourably for farmer. The factors gave rise to a condition for development of high-fertilizer-response varieties in the later period.

Although function of landlord in the technological changes in the subsequent period should be discussed, we would like to touch upon with only two respects in contrast to earlier function of landlords, as follows.

1) The landlords changed to a rentier type of landlords by the end of the last century. They had no interest in their tenant's farming except recieving constant rent. Under this land tenure system the amount of products to landlords was increased, but the share of products to tenant farmers was also increased gradually in line with the yield increase. The farmers were derived more and more to introducing high-yielding varieties and intensive fertilizer application.

2) Needless to say, the land reform in post war II expelled the absentee-ownership. Especially land improvement, which had been impeded under the land tenure system, has been splendidly performed under the owner-cultivator system in this period.

It is clear that the increase of yield in post war II has been realized by heavy application of fertilizer and adoption of better high-response varieties, which have been facilitated by such inputs as land improvement and higher education as well as declining real price of fertilizer.

V Some Implications for Agriculfural Development in Underdeveloped Countries

The Japanese experience indicates that new varieties of rice have been developed by stages in its own way in response to local conditions and needs. At the earlier stages, effort was made to develop every kinds of varieties which did not require much of expensive commercial fertilizer. Early development of rice yield was brought about by such kinds of varieties. It is only in the later period to find high-response varieties, which are associated with by cheaper source of fertilizer supply.

New high-response varieties of rice, however, are now available in most underdeveloped countries in spite of nigerdly availability of commercial fertilizers. In these countries fertilizer prices have been substantially above world prices because of the small demand, poor marketing arrangement policy and controls. Moreover, the availability of inputs such as irrigation and pesticides is limited extremely. In spite of such unfavorable conditions high-response varieties which demand water control, pest control weed control as well as more fertilizer have been developed by application of imported agricultural scientific knowledge from advanced countries. This development process of new varieties differs from Japanese process in term of fertilizer responsineness. Judging from Japanese experience, it is considered that more effort should be made on research and development of better low-response varieties under a circumstance of high cost of fertilizer input. Hence, it is interesting to analyze economic results of adopting high-response varieties at the range of prevailing prices for rice and fertilizer input in underdevloped countries, and to examine what changes in other complementary inputs are demanded for the succesful adoption.

I.R-8 has been paid notable attention as the most superior variety having higher yield and resistivity to heavier aplication of fertilizer among new varieties of rice developed recently in underdeveloped countries. Data of Indian agricultural experiment stations (Fig. 8) show that I.R.-8

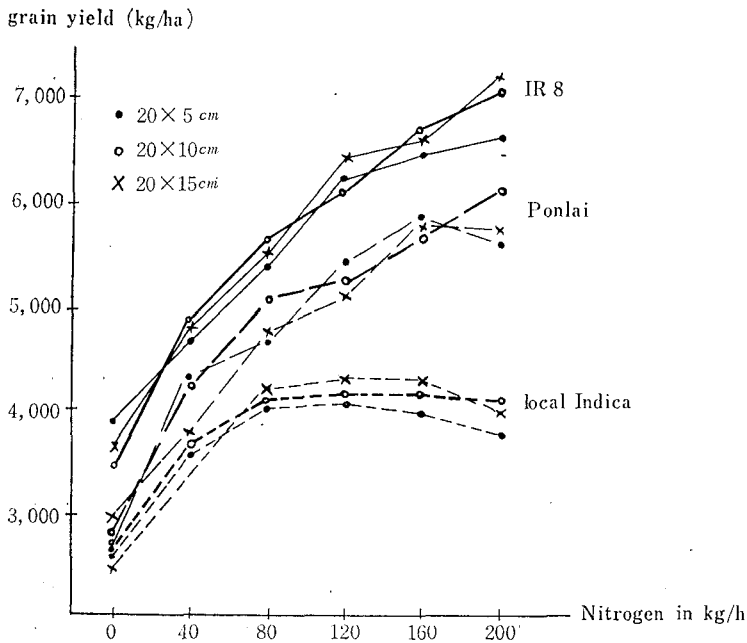

Fig. 8 Average effect of Nitrogen and Spacing on grain yield in the nvs trials, Rabi 1968.

presents higher yield than ponlai and local varieties at every level of nitrogen applications, and its responsiveness to nitrogen is higher than other varieties. Apparently, the adoption of I.R.-8 will provide an attractive return for those Indian farmers who have conditions similar to those of the experiment stations from which these data were taken. This is consistent with the fact that I.R.-8 has been adopting rapidly in the progressive agricultural areas favoured by irrigation and drainage facilities. However, water supply arrangements which are essential for the cultivation of such high-yielding variety are almost non-exist in most areas. Furthermore, I.R.-8 demands additional labor and physical inputs in more intensive weeding, cultivation, and more careful control of pest, for which there is a limit to extensive cultivation. Though most agricultural economists have reported that I.R.-8 would privide an attractive

return for farmers in the progresive agricultural areas favoured by irrigation and drainage facilities*, it seems that there is a strong possibility that farm income may decrease instead of increasing if I.R.-8 is not accompanied by high levels of fertilizer, pesticides, and irrigation. Under unfavoured conditions in most areas where water supply arrangements are almost non-exist, more effort should be made to develop new varieties which do not require much of expensive commercial fertilizers and pesticides, and adapt well to local conditions. Even in the progressive agricultural areas, the succesful adoption of I.R.-8 will be dependent upon many socio-economic factors such as provision of security of tenure, incentive-oriented farm price policy, institutional factors such as the establishment of a good net work of communication facilities, provison of adequate and timely credit for the purchase of commercial fertilizers and pesticides, etc. Better high-response varieties such as I·R.-8 by themselves are not a panacea for the production ills of underdeveloped countries.

*For example, I.J.Singh, T.K. Chowdhury and Dinkar Rao attempted to study the response of three varieties of paddy, I.R.-8, Tainan-3 and China-4 to various levels of nitrogen application, and compare the total revenue, total cost and net profit due to the application of nitrogen on the three varieties of paddy. The most profitable level of nitrogen application and net profit incident to nitrogen application from each varieties are shown in Table 1. At the most profitable level of nitrogen appilcation, net profit per hectare due to nitrogen application was higher from I.R.-8 than from Tainan-3 and China-4.

Tabl.1 Quantity of Nitrogen Applied and Net profit per Hectare due to Nitrogen Application at The Most Profitable level of Nitrogen Application.

variety	Most profitable levelof nitrogen (kg)	Total revenue (Rs.)	Total cost (Rs.)	Total profit (Rs.)
I.R.-8	151.2	1,008.9	279.1	729.8
Tainan-3	95.9	779.0	177.0	602.0
China-4	57.4	272.9	106.9	166.9

I.J.Singh, T.K.Chowdhary and Dinkar Rao, "Response of some high-yielding paddy varieties to nitrogen : An Economic Anaysis," Indian Journal of Agricultural Economics, Vol. XXIII, Oct-Dec. 1968.

VI Conclusion

It is widely assumed that better high-response varieties such as I.R.-8 play a crucial role for agricultural development in underdeveloped countries. However, the successful adoption of such varieties appears to be limited by the availability of certain vital inputs such as commercial fertilizer and irrigation. In fact, Japanese experience indicates that in the earlier period when availability of fertilizer was limited and its real price was high, the low-response varieties were prefered in farmer's choice of varieties and in research and development of varieties as well. As cheaper source of supply of commercial fertilizer has been made available, high-response varieties have been profitably chosen by the farmers. Early development of rice yield was brought about by such kinds of varieties which did not much of expensive commercial fertilizers and pesticides.

The role of londlord in agricultural development should be appraised by what he has done practically, but adjustment of land tenure systems should be devised to respond sensitively to new opportunities opened by improved varieties and better production practices in such a way to strengthen the economic incentives of farmers.

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