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A NOTE ON DEFINING APPROPRIATE TECHNOLOGY

by Jose Encarnacion, Jr., 1928-

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A NOTE ON DEFINING APPROPRIATE TECHNOLOGY

by J. Encarnación

The purpose of this note is to sketch a model that brings out the various assumptions needed in order to define at the macro level the appropriate technology[1/] for a developing economy where greater employment is a major policy objective. Appropriate technologies at sectoral levels can then be identified by making further assumptions regarding other objectives and constraints facing the economic planner. As should be expected, the appropriateness of a technology depends on the objectives being pursued as well as the structure of the economy. The model to be presented[2/] seems to be the simplest one possible containing the important elements necessary for the task. It can obviously be elaborated or complicated in various directions, but our aim here is merely to set out a framework in which further complications can possibly be embedded.

Assume an aggregate production function homogeneous of degree one:

$$Y = F(K, N) = f(k)N \tag{1}$$

where K is the capital stock, N is employment, $f(k)$ is output per worker and $k = K/N$. We also assume that the saving fraction $s = S/Y$ is a function of k:

$$s = g(k) \tag{2}$$

We expect both f(k) and g(k) to be increasing functions of k. In the latter case, the reason would lie in the income distribution implications of different capital-labor ratios and the different propensities to consume of rentiers vs. wage-earners.[3]

The capital stock at the beginning of the next period will be greater by the amount ΔK. Suppose that

$$sY = \Delta K \tag{3}$$

on the assumption that capital formation is financed wholly by domestic saving.[4] Suppose further that

$$\Delta K/\Delta N = k \tag{4}$$

so that the aggregative capital-labor ratio next period will be the same as that of the current period. This is not to say that we need to assume k to be a constant, but only that this is the simplest assumption to make regarding possible changes in k from one period to the next.

Substituting from (1)-(3) into (4) we have

$$g(k)f(k)N/\Delta N = k \tag{5}$$

or

$$g(k)f(k) = nk \tag{6}$$

where $n = \Delta N/N$. If a policy decision is made as to the growth rate of employment n,[5] (6) can be solved for the required capital-labor ratio, k^*, corresponding to the appropriate technology (see Fig. 1). On the other hand, the actual growth rate of employment is determined by the actual capital-labor ratio in accordance with (6).

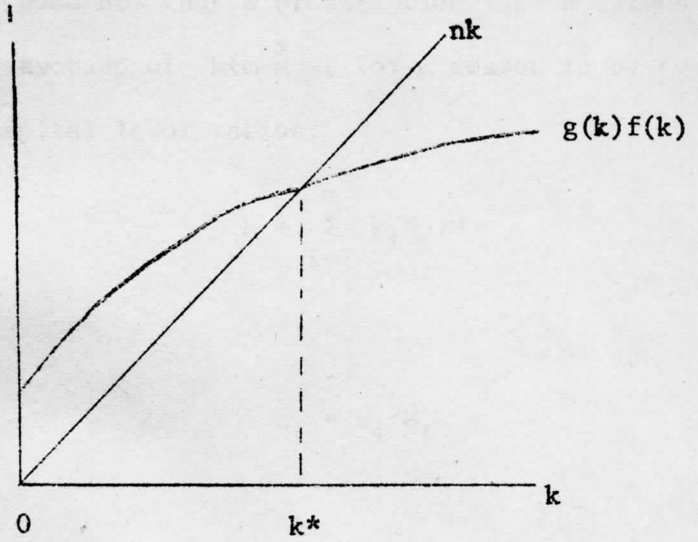

Figure 1

There are thus two ways of looking at (6): as a normative proposition or as a descriptive one. The variable n could be preselected as a policy decision, thus determining the k required. Alternatively, given the existing k, the growth rate of employment is determined.

Several implications are immediate: Higher productivity and higher propensities to save permit a higher k; so does the augmentation of domestic saving by foreign saving. A higher n requires a lower k; conversely, if the existing k is "too high," the growth rate of employment will not suffice to employ net additions to the labor force over time. This appears to be the prevailing situation in the developing economies where the technology in use is merely adopted from the more advanced countries where labor force growth rates are lower.

Suppose now that a prescription for n fixes k, which is a weighted average of $m(m \geq 4$, for a reason to be seen shortly) sectoral capital labor ratios:

$$k = \sum_{i=1}^{m} k_i N_i / N \tag{7}$$

where

$$k_i = K_i / N_i \qquad (i=1, \ldots, m) \tag{8}$$

and

$$K = \sum_{i=1}^{m} K_i \tag{9}$$

$$N = \sum_{i=1}^{m} N_i \tag{10}$$

Suppose that

$$Y_i = f_i(k_i) N_i \qquad (i=1, \ldots, m) \tag{11}$$

and

$$Y = \sum_{i=1}^{m} Y_i \tag{12}$$

We observe that (7)-(12) constitute $(2m + 4)$ equations in the 4m variables k_i, K_i, N_i and Y_i $(i=1, \ldots, m)$, given that k, K, N and Y have already been determined at the macro level. It may be expected that policy decisions or demand conditions would determine the Y_i's, in which case we would be left with $(m - 4)$ degrees of freedom. There may not be much room for choice, however, if the available techniques are such that

$$(13) \qquad a_i \leq k_i \leq b_i \qquad (i=1, \ldots, m)$$

and the ranges (a_i, b_i) are relatively narrow. The possibility here arises that (7)-(13) might have no solution with the Y_i's independently given.

Assuming some room for choice regarding the k_i's and N_i's, what those particular choices will be would have to depend on specific policy objectives such as increasing employment in some sectors relative to others. Appropriate technologies cannot be identified without a statement of those objectives.

FOOTNOTES

1/ There is a growing literature on the question of appropriate technologies for developing economies. See L.E. Westphal. "Research on 'Appropriate' Technology," paper presented at the Conference on Technology, Employment and Development, sponsored by the Council for Asian Manpower Studies, held at Penang, January 3-5, 1973, for a thoughtful survey of the issues involved. See also the references cited in Westphal's paper and other papers presented at the Penang conference.

2/ Cf. a similar model in J. Encarnación, "Some Elements of Economic Theory," Chapter 3 (esp. p. 3-56 ff.) in G.P. Sicat et al., Economies and Development: An Introduction, University of the Philippines Press, 1965, which itself is adapted from J.H. Power, "Capital Intensity and Economic Growth," American Economic Review, May 1955.

3/ Even when relative income shares are unchanged as with a Cobb-Douglas production function under profit-maximizing competitive assumptions, varying N with the same K will have an effect on s.

4/ To the extent that foreign saving is made available, ΔK would be larger.

5/ A logical candidate for the long-run value of such a policy variable would be the growth rate of the labor force.

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THE PROBABLE IMPACT OF THE SEED-FERTILIZER REVOLUTION ON GRAIN PRODUCTION AND ON FARM LABOR REQUIREMENTS*

by

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THE PROBABLE IMPACT OF THE SEED-FERTILIZER REVOLUTION ON GRAIN PRODUCTION AND ON FARM LABOR REQUIREMENTS*

Randolph Barker, Mahar Mangahas, and William H. Meyers**

There is considerable controversy as to the effect of the current seed-fertilizer revolution on production and employment. This controversy stems in part from the fact that we have had too little time to assess this impact. The high yielding varieties spread most rapidly in the period beginning about 1968. There are a number of case studies that have described their impact in specific locations. But it is difficult to interpret from these studies the changes in aggregate or national production and employment which can be attributed to the new technology.

Introduction of the high yielding varieties began in the Philippines in 1966, and at present approximately one-half of the rice-growing area is planted to these fertilizer-responsive varieties. Aggregate data are now available which begin to provide some indication of the impact of the seed-fertilizer technology on production. In this paper we plan to present the results of case studies in combination with the results of aggregate analysis in assessing as accurately as possible the probable effect of the seed-fertilizer technology on production and farm labor requirements in the Philippine rice sector. Use is also made of aggregate labor statistics to develop labor absorption functions. Unfortunately, however, statistical data are available only through 1968, and thus, no conclusions can be drawn as yet from this approach.

IMPACT ON PRODUCTION

Before observing changes that have taken place in Philippine rice production in the aggregate and at the farm level, we discuss briefly the yield levels that can potentially be achieved through the use of high yielding varieties.

Yield Potentials

The yield potentials for the high yielding varieties are shown in the experiment station functions - Figures 1 and 2. 1/ Most of the experiments upon which the figures are based were conducted in 1968. High

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1/ These figures were presented in an earlier paper by the authors. See, Randolph Barker and Mahar Mangahas, "Environmental and Other Factors Influencing the Performance of New High Yielding Varieties of Wheat and Rice in Asia," Proceedings of the XIV Int'l Conference of Agricultural Economists, Minsk, U.S.S.R., 1970.

yielding varieties subsequently released have had better grain quality and/or more resistance to insects and diseases. Many of these new varieties have the same yield potential as IR8, but none have produced consistently higher yields. Thus, IR8 represents at least a temporary yield plateau. How soon this plateau will be penetrated is a matter of debate. A gradual increase in the yield ceilings in the future is far more likely than the dramatic breakthrough represented by the introduction of IR8.

The yield potential is much lower for the wet than for the dry season (5 tons vs. 7 tons) as a result of the heavy cloud cover and low level of solar energy in the monsoon season during the critical grain ripening period. The level of solar energy in the four to six weeks before harvest has a significant impact on yield response to fertilizer.

The yield potentials shown in Figures 1 and 2 are for irrigated areas, and up to the present, this is principally where the high yielding varieties have been planted. However, there is a growing interest in research on non-irrigated rice which accounts for at least three-quarters of the rice-growing area in Asia. 2/ Although the yield potential of this area will remain low, raising the potential will be of significant benefit to the large number of farmers who will continue to grow rice under non-irrigated conditions for the foreseeable future.

Growth in Philippine Rice Production

The analysis in this section is based upon the official records of the Bureau of Agricultural Economics, Department of Agriculture and Natural Resources. Their Crop and Livestock Survey provides estimates of rice production and area harvested as well as other information such as area of land irrigated and area of high yielding varieties. The survey has been conducted annually since 1954 in the period from March to June, and through the years improvements have been introduced into the sampling design and other features of the survey.

The analysis presented in Tables 1 to 4 draws on information obtained principally after 1960. During this period, the survey employed a multistage sampling technique with villages (barrios) as the first-stage sampling units and farm households as the second-stage sampling units. 3/ Barrios were stratified according to palay density (main strata) and geographic criterion (sub-strata). From 1961 to 1968, approximately 6000 sample farm households were drawn for a national sampling fraction of 1/350.

2/ The nature of this research is discussed in more detail in Randolph Barker, "The Evolutionary Nature of the New Rice Technology," Food Research Institute Studies (Stanford University), Vol. X, No. 2 (forthcoming).

3/ Details of survey procedures can be found for the period 1954-65 in I. P. David, Development of a Statistical Model for Agricultural Surveys in the Philippines, Unpublished Masters thesis, U.P. College of Agriculture, Los Baños, Philippines, 1966. Details of more recent changes are found in Bureau of Agricultural Economics, BAEcon Surveys for Rice and Corn, August 1971, Diliman, Philippines.

Beginning in the crop year 1968-69, the survey procedure was revised and the farm household sample increased to 11,363. Research studies indicate that there has been a tendency to overestimate area and underestimate production with the result that yields are also underestimated. 4/ If the improvements made since 1968 have succeeded in reducing these errors, there could be a bias in the time-series trends. However, it is our opinion that in spite of weaknesses, these figures provide a reasonably accurate estimate of the national trends in production. 5/

Fifty tons of IR8 seed was released to the Philippine Government in August 1966. The seed was multiplied during the 1966-67 crop year. The first major planting of this high yielding variety occurred in the wet season (first half) of the crop year 1967-68. The percentage of lowland rice area planted to high yielding varieties is shown for four successive crop years in Table 1 for the Philippines and for five regions. 6/ It is well known that for the most part these new varieties have been planted in irrigated areas. However, there has also been a steady increase in plantings on rainfed areas. This is apparently explained by the fact that many rainfed farmers found that these varieties seemed to recover well from droughts frequently experienced early in the growing season. The performance of rice varieties under adverse water conditions is a subject that has not yet been fully explored.

Table 2 shows the growth in production, area, and yield for the post-war period computed by taking the average of three crop years. Yields remained rather constant before 1960 but crop area expanded rapidly keeping pace with population growth. After 1960 the pattern reversed. Crop area remained constant but yields rose stimulated in part by a rise in the percent of crop area irrigated. Although data are not available to show the recent trend in total cultivated area, it seems apparent that with the expansion of dry season irrigation the land base in rice has declined. The alternative crops that have been substituted on the marginal rice land undoubtedly include corn and sugar cane.

4/ David, op. cit. and K. A. Gomez and B. T. Oñate, "Response Bias in the Collection of Rice Statistics," The Philippine Agriculturist, Vol. LII, Feb.-March 1969, pp. 602-613. In the latter study, actual measurements were made of harvesters' share and of area to check the accuracy of the farmers' response in a sample of 68 farms in Laguna Province. Area was overestimated on the average by 5.6 percent. The magnitude of underestimation in the production is not clear from this study.

5/ The estimates of the Bureau of Ag. Economics are frequently criticized by policy makers and others who have attempted to use these as a basis for determining for a given year the level of national self-sufficiency and import and export requirements. The futility of this exercise is discussed in Mahar Mangahas, "Efficient Forecasting and Philippine Rice Import/Export Policy," Proceedings of Seminar on Consumption and Marketing of Rice in the Philippines, IRRI, Los Baños, Philippines, December 1969.

6/ In the Bureau of Ag. Economics, data are normally reported for 9 regions in the Philippines. The sample survey coefficients of variation (CVs) for the entire Philippines in 1970 were 2.51 percent for area and 2.66 percent for production. For some of the regions, however, these CVs exceeded 10%. We therefore reduced the number of regions from nine to five by combining two regions in Northern Luzon, two regions in Southern Luzon, two regions in the Visayas, and two regions in Mindanao.

Three major factors affecting production growth are the change in irrigated hectares, the change in non-irrigated hectares, and the change in yield per hectare. The effect of each of these factors to the growth in rice production is shown in Table 3 for the Philippines and for five regions. From 1948 to 1960 contribution to growth was fairly evenly divided between all three factors. In the early 1960's the lowland rainfed rice area declined largely as a result of strong competition from an expanding sugar industry. Due to a decline in the crop area the production growth rate was sharply lower and depended entirely on growth in yield per hectare. In the late 1960's, irrigation expansion in Luzon has been the dominant factor contributing to the 4.6 percent per annum growth rate, and yield increases have also played a significant role. There has been a decline in rainfed lowland rice as some of the former rainfed areas have become irrigated. There has also been a decline in the area planted to upland rice principally in Southern Luzon and Mindanao.

What can we say was the impact of the introduction of high yielding varieties upon production growth? The yield contribution alone to annual growth in output is about 2.7 percent per annum between 1964-66 and 1969-71. In addition, it must be recognized that the expansion of irrigated areas as well as the decline in non-irrigated areas may have been the direct or indirect result of the introduction of high yielding varieties. It is impossible to consider these effects independently, and thefore, impossible to say precisely how much of the 4.6 percent annual growth rate should be credited to high yielding varieties. Nevertheless, what is particularly significant in this analysis is the very important role played by irrigation

Results of Farm Surveys

The results of farm surveys can provide further evidence of changes taking place in productivity and resource use following the introduction of high yielding varieties. These micro studies bring to light changes that are often obscured in national statistics. In this section we examine briefly the results of two surveys. The first was conducted in Laguna Province, one of the better rice-growing areas in the Philippines. The second was conducted in the province of Nueva Ecija in Central Luzon, the largest of the rice-growing areas in the Philippines.

Table 5 shows changes taking place between 1966 and 1969 in adoption of high yielding varieties, use of nitrogen fertilizer, and grain yield in a sample of 152 farms from three municipalities of Laguna Province. Farmers in Cabuyao and Calamba have been able to achieve yields in excess of 4 tons which compares favorably with the yield potentials for the wet season shown in Figures 1 and 2. On the other hand, perhaps

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7/ A recent visitor to the International Rice Research Institute, who was undertaking a feasibility study for irrigation, indicated that he was having difficulty convincing some agencies of the need for continued investment in irrigation now that high yields and low rice prices were just around the corner.

due to poorer soil and water conditions, the yield of the high yielding varieties in Biñan was only about 3 tons despite an application of 50 kg. of nitrogen per hectare. In Calamba and Cabuyao, two crops of rice are grown each year but in Biñan there is adequate water for only 3 crops in two years.

Figure 3 and Table 6 indicate the changes in inputs and productivity based upon a sample of 513 farms in the municipality of Gapan, Nueva Ecija Province. The majority of farms in this municipality receive enough water from the gravity irrigation system to grow two crops of rice. These two-crop irrigated farms were 95 percent in high yielding varieties by 1970. Table 6 shows clearly that during this period these farms moved from a yield plateau of 2.2 tons with local varieties to a new plateau of 3 tons with high yielding varieties. In only one of the 10 villages of Gapan were yields in 1970 significantly higher than 3 tons per hectare (San Nicolas averaged 3.7 tons). Again, as in Biñan, the new yield plateau seems to be well below the 4 to 5-ton potential. The reasons are not obvious. Soil and water conditions as well as management practices should be carefully examined as an initial step to identifying the constraints to further yield increases.

Implications

Both the aggregate estimates and the farm survey results tend to confirm the fact that significant yield gains have been made through the introduction of high yielding varieties, but that these yield gains have not come up to the expectations of scientists and policy makers alike. 8/ In the irrigated areas, where the percentage of high yielding varieties is very large, yields of high yielding varieties exceed local varieties by about 11 percent for the nation as a whole, but by as much as 50 to 100 percent in some selected areas. The failure to achieve the production potential can be attributed to low input levels on many farms that have switched to high yielding varieties. However, there appears to be in some areas other agro-economic factors not completely in the farmer's control that may be limiting yield growth. Research needs to be undertaken to identify these factors more clearly.

At present, it would appear that the Philippines is marginally self-sufficient in rice production. Unfavorable weather conditions or insect problems, such as occurred in 1970 and 1971, can result in rice imports, but on the average the growth in rice production seems to be keeping pace with population. Whether this continues in the future will depend on further investments in irrigation as well as on higher yields per hectare.

8/ A separate set of government statistics on rice released by the National Food and Agricultural Council (NFAC) is at variance with these findings. In October 1971, they reported that the yields of high yielding varieties continued to average about double those of the traditional varieties. These estimates are not based upon normal statistical sampling procedures. Furthermore, if these estimates were accurate, it would follow that the Philippines would be exporting large surpluses of rice instead of importing in 1971. We have thus chosen to ignore the NFAC figures in our analysis.

IMPACT ON FARM LABOR REQUIREMENTS

In the previous section we have shown that since 1960, crop area has remained almost constant. The growth in rice production has been primarily a result of increases in yield per hectare and in the percentag of area irrigated. Under these conditions, three major changes can affec total labor use in the rice sector: an increase in labor input per hectar due to the new rice technology, a decrease in labor input per hectare due to labor-saving mechanization, and an increase in average labor input per hectare as the irrigated and more labor-intensive portion of total crop area increases. 9/

Our research provides considerable information on the first two factors. As mentioned in the previous section, increases in the percenta of crop area irrigated may be influenced by the new rice technology, but we have no data which can distinguish the cause and effect relationship.

Direct Effect on Labor Input Levels

Comparing labor input levels on all farms in 1966 and 1970 from the Central Luzon-Laguna Survey (Table 7), we find that land preparation labor declined while transplanting, weeding, and harvesting-threshing labo increased sufficiently to raise the total labor input. Also, on balance, the proportion of hired labor increased. Looking at the labor inputs for areas planted to local and high yielding varieties in 1970, it is clear that it was the more intensive labor use for high yielding variety production which raised both the total and hired labor inputs for 1970 above their 1966 levels.

The two tasks which account for most of the increase in labor inpu are weeding and harvesting-threshing. One expects that the new seed-fertilizer technology by increasing the marginal productivity of labor particularly between transplanting and harvesting, would induce higher labor input levels. While this effect is evident for the weeding task where the labor input more than doubled between 1966 and 1970, no similar change occurred in other pre-harvest tasks.

It is interesting to note that while the weeding input was growing from 5 to 11 man-days per hectare, the use of rotary weeders was also increasing. Another study covering three progressive areas of Laguna Province shows an average weeding labor input of 18 man-days per hectare while 84 percent of the farmers were using the rotary weeder. Table 8 shows that in both areas the rotary weeder complements rather than replace other forms of weeding. In the Central Luzon study, 16 percent of the farmers are not weeding at all, while 65 percent use either hand weeding or a combination of chemicals and hand weeding. Over time these farmers may move toward the pattern in the Laguna area where most farmers prefer a combination of all three methods of weeding.

9/ An increase in double-cropping, cet. par., would have an even greater effect. However, though data on this factor is lacking, it appear that any recent increase in double-cropping tends to be off-set by a decline in rice land area.

The use of rotary weeders requires straight-row planting which means a higher labor input for transplanting. There is some evidence of this in the Central Luzon-Laguna data on Table 7, but the much lower transplanting labor input in the Laguna study appears to be due to the prevalence of the labor-saving dapog seedbed method. 10/

The increase in harvesting-threshing labor is a natural consequence of higher yields, provided that the threshing technology remains unchanged. As yields increase, however, the labor requirement per unit of output declines even if the technology does not change. From the data in Table 7, it can be shown that the required man-days per ton of grain harvested and threshed declined from 9.5 in 1966 to 7.8 in 1970, while the number of thresher users changed only slightly. It would appear, therefore, that the higher yields have an even greater impact on labor productivity than on labor absorption.

In summary, the new seed-fertilizer technology appears to have a measurable effect on the labor used for weeding and harvesting-threshing tasks. The difference in total labor use between local and high yielding varieties is essentially a result of the shift in the production function. However, it is important to emphasize that the difference in labor input of 9.5 percent (from 63 to 69 man-days) in Table 7 is quite small in comparison to the difference in yield of about 26 percent. The result is a sharp difference in labor productivity, which is what we should expect from the new technology.

Effect on Mechanization

We have shown elsewhere that changes in tractor purchases during the past five years appear to be less correlated with the release of high yielding variety seeds in August 1966 than with the agricultural mechanization loan program initiated by the Central Bank of the Philippines and the International Bank for Reconstruction and Development in April of the same year. 11/

10/ The dapog method involves the germination and growth of seedlings on banana leaves or on polyethylene sheets where the roots are unable to make contact with the soil. After 9 to 14 days, the seedlings are simply rolled into a bundle and transported to the field for transplanting. A description is contained in University of the Philippines, College of Agriculture, Rice Production Manual, 1970.

11/ Randolph Barker, William H. Meyers, Cristina M. Crisostomo, and Bart Duff, "Employment and Mechanization in Philippine Agriculture," Paper prepared for the International Labor Office of the United Nations, Geneva, Switzerland, October 1971.

This finding is confirmed by the results of a survey of 76 farms in Central Luzon and Laguna - areas where the highest mechanization rates are found - which indicate that, although the percentage of tractor users in the wet season increased rapidly since 1966, the 1970 percentages are the same for both local and high yielding varieties (Table 7).

The case of mechanical threshers is quite different. Their use does not appear to be increasing with time and the percentage of users in the wet season is substantially lower on the high yielding variety area (Table 7). This can be explained by noting that these are large stationary type threshers which are normally moved into the rice fields only after the fields are dry. As double-cropping and the use of early maturing high yielding varieties move the first crop harvest deeper into the rainy season, it becomes more difficult to use this thresher. 12/ Therefore, the introduction of high yielding varieties appears to have, if anything, a slightly negative effect on the use of this particular thresher technology Increased grain yields, however, may eventually induce farmers to look for a mechanical thresher which is more adpated to present conditions.

The simple rotary weeder is the one type of mechanization which Table 7 shows to be more prevalent in the area planted to high yielding varieties. However, unlike tractors and threshers, this appears to be a labor-complementing rather than a labor-substituting machine as already not

Implications

The farm surveys indicate that the introduction of the new rice technology has contributed to an increase in labor demand in the rice secto However, since the new technology has an even greater effect on labor productivity, the long run implications are that with the new technology it will take less labor to supply a given quantity of rice, and the incrementa employment-output ratio will probably be lower than it has been in the past

AGGREGATE EMPLOYMENT DATA

The only source of labor force and employment time series data is the Bureau of the Census and Statistics Survey of Households (BCSSH). A biannual (May and October) series of estimates is available from nationwide

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12/ Results of the Gapan surveys indicate that these threshers are an old and declining technology. The survey of all thresher owners in the municipality of Gapan, Nueva Ecija, revealed that 73 percent of the threshers now operating were introduced between 1936 and 1960. The survey of farmers showed that the percentage of wet season thresher users declined from 51 percent for 1960 to 29 percent in 1970, and most of those who discontinued thresher use for the wet season crop said it was because they began double-cropping and had no time to wait for the ground to dry.

sample surveys for 1956-68 (see Tables 9 and 10). Data for 1969 and 1970 are not yet available for various reasons. 13/ This is somewhat unfortunate, since the effect of high yielding varieties on total employment in agriculture could not date earlier than 1968. This is therefore the only year for which aggregate data might be inspected for effects of recent technological change. Details for 1966-68 as to sex are available for rice and corn farms in particular (Table 11).

In their detailed compendium of the available survey data, Mijares and Tidalgo 14/ have clearly described the magnitude of the Philippine employment problem. During 1956-68, the totally unemployed have ranged from 5 to 10 percent of the labor force. This is in spite of a definite drop over time in the labor force participation rate in the 10-24 age cohort (the drop is more pronounced in agriculture than in non-agriculture). The unemployment problem is not as severe in agriculture as it is elsewhere. Data for 1956-68 indicate that the urban rate is about one percentage point above the national mean and the rural rate about one percentage point below it. Half of the totally unemployed are in the 15-24 age group, and a greater proportion of the unemployed than the employed have reached high school or college. Among experienced workers, those in non-agriculture spend two weeks to two months more time looking for work than those in agriculture.

Underemployment is high: one-fourth of those employed want more work, three-fifths of these being in agriculture. About 15 percent of those subjectively underemployed already work 50 or more hours per week, and another 35 percent already work between 40 and 50 hours per week. Using the 40-hour per week standard, the unemployed plus the full-time equivalent of the underemployed have ranged during 1956-68 from 8.5 to 14.6 percent of the labor force, using the October series. Using the 50-hour standard, the range is from 11.5 to 16.7 percent. The ranges are slightly narrower at both ends if the May series is used.

Most analysts of Philippine employment data have limited themselves to the October series. The stock reason offered is that "the October series is more representative of conditions during the year than the May series ... It has more stability since October falls within the season 15/ for harvesting and planting and schools are in session during this month." 16/

13/ Preliminary 1969 estimates turned out quite unreasonable, and were not published. This was the first year in which electronic data processing was used on the labor force survey, and it is felt that errors in the EDP may have been made. The Census Bureau still hopes that corrections can be completed. In 1970 the labor force survey gave way to the census on population and housing; processing of the employment portion of the census has not been completed.

14/ T. A. Mijares and R. L. Tidalgo, "Labor Absorption in the Philippines," Paper presented at the Conference on Manpower Problems in East and Southeast Asia, Singapore, May 1971.

15/ Seasonality of work is to some extent allowed for in the calculation of employment. From 2 to 6% of the employed labor force in agriculture are classified as not at work (during the survey week); of this, from 40 to 50% are ill, and from 20 to 40% are seasonal workers not at work. See Mijares and Tidalgo, Ibid, Table 18.

16/ Mijares and Tidalgo, Ibid, p. 18.

The data do not appear to bear these statements out, however. Following the May series, the national labor force has risen each year except for 1959, and agricultural employment has risen each year except for 1965. In the October series, the national labor force falls in 1963 and 1968; is supposed not to have changed in 1960 from 1959; and rises in 1966 over 1965 by about one million persons (a 9.2 percent increase). The October agricultural employment series drops in 1960, 1963, 1964, 1965 and 1968; and in 1966 it rises by about half a million persons (a 9.9 percent increase) over the previous year. 17/

The 1968 data are particularly problematical. The national labor force is estimated to have fallen by about 400,000 from October 1967 to October 1968, but to have risen by about 260,000 from May 1967 to May 1968. The estimates of agricultural employment and of employment on rice and corn farms in particular follow the same pattern. Sampling errors published by the BCS (footnotes to Tables 9 and 10) do not account for these peculiarities. 18/

In the macroanalysis described here, the agricultural employment variable used is the simple May-October average, on the following grounds: (1) it incorporates more information than the October statistics alone, and (2) it almost always performs better than the October figure (higher t-ratios and $\overline{R}^2$'s) as either an explanatory variable for sectoral value added or a dependent variable in sectoral labor-absorption functions. 19/

Measuring employment by the May-October average, the 1968 level of employment was 11,429 thousand. About 56 percent of these were in agriculture, 25 percent in commerce and services (or the S sector), and 19 percent in the industrial sector (manufacturing taking 11-1/2 percentage points). The share of agriculture in employment had decreased by about 4 percentage points in 12 years.

17/ T. K. Ruprecht, "Philippine Labor Force Statistics: A Critique and Recomputation of PSSH Data," The Philippine Statistician, Vol. 15, Nos. 1-2, March-June 1966. Ruprecht's critique and reestimation of Philippine Labor Force statistics covers the period 1956-62. He called attention to errors not merely due to sampling, response and enumeration but due also to the prolonged use of an incorrect population base. His reestimates of employment in agriculture exceed the published data by about 8 percent. However, the instability in growth rates is maintained in Ruprecht's series; his October series growth rates, annually from 1956 to 1962, are 9.9 percent; 5.2 percent; 0.4 percent; -1.5 percent, 5.7 percent; and 7.2 percent.

18/ One speculation is that a substantial number of females employed on rice and corn farms sought employment in non-agricultural positions in the latter part of 1968 on account of the drought during that wet season.

19/ The sectors referred to are: (1) agriculture, fishing and forestry, (2) mining and quarrying, (3) manufacturing, (4) constructions, (5) transport, storage, communications and utilities, (6) commerce, and (7) services.

Students of employment in the Philippines have concentrated their attention on the relatively low rate of labor absorption in the manufacturing sector (Sicat 20/, Williamson 21/, Ruprecht 22/).

The bias in favor of capital in postwar economic policies in the Philippines is well known -- the over-valued currency in the fifties, with exchange control favoring capital imports; minimum wage laws; subsidized credit for capital purchases; tariff and tax exemptions on favored capital-intensive industries; a tariff structure favoring import-dependent import substitution and hindering backward linkages. Ruprecht 23/ called attention to the tremendous increases in the capital-labor ratio in manufacturing over 1957-62. Williamson 24/ successfully showed the dependence of employment in manufacturing on the user cost of capital, from a pool of two-digit industries.

Labor Absorption Equations

In this section we give a preliminary report of an attempt to estimate labor absorption functions for each of seven value-added sectors from annual data for 1956-68. 25/ Attention is focused on the results for the agricultural sector. Sectoral employment was regressed on various combinations of the following variables: value-added, the sectoral wage rate, the sectoral price index, and the general price index. Wage-price ratios have been tried, and one-period logs for both dependent and explanatory variables have been tried. Only simple linear specifications have been used so far (later trials will use first differences and log-differences). Wage rates were treated as predetermined variables, on a preliminary basis. The elasticities of sectoral employment at the means from the 'best' regressions are summarized in Table 12.

In particular, the elasticities of sectoral employment with respect to own-sector value-added are roughly as follows:

20/ G. P. Sicat, "Labor Policies and Philippine Economic Development," University of the Philippines, School of Economics Discussion Paper No. 69-4, February 7, 1969.

21/ J. G. Williamson, "Capital Accumulation, Labor-Saving and Labor Absorption: A New Look at Some Contemporary Asian Experience," Social Systems Research Institute, University of Wisconsin, Workshop Series Paper EDIE 6932, 1969.

22/ Ruprecht, op. cit. Also, T. K. Ruprecht, "Labor Absorption Problems and Economic Development in the Philippines," The Philippine Economic Journal, Vol. 5, No. 2, 1966, pp. 288-312.

23/ Ruprecht, "Labor Absorption Problems ....", Ibid.

24/ Williamson, op. cit.

25/ This research forms part of a broader study whose objective is to estimate a short-term macro-model of the Philippine economy for purposes of planning.

1.	Agriculture, fishing & forestry	0.7
2.	Mining and quarrying	2.5 (weak $\bar{R}^2$)
3.	Manufacturing	0.5
4.	Construction	1.0 (weak $\bar{R}^2$)
5.	Transport, Storage and Communications & Utilities	1.2
6.	Commerce	1.3
7.	Services	1.1

It is interesting to find that the agricultural wage rate plays some measurable role in determining agricultural employment, although its coefficient is not significantly different from zero at the 10 percent level. What is significant is that the employment-output elasticity at the means is 0.7; whereas the simple ratio of the average annual rate of growth of agricultural employment (2.5 percent) to the average rate of growth of agricultural value-added (4.5 percent) over the period 1956-68 is only 0.56. 26/ A gradual increase in agricultural wages over the period accounts for the difference in estimated employment-output elasticities. The employment elasticity in manufacturing is low, as would be expected. The equation, with only manufacturing value-added as explanatory variable, is however still unsatisfactory. It would be expected, following Williamson's 27/ results with disaggregated manufacturing data, that a specification, including capital prices, would yield better results. Almost all the other employment elasticities are larger than one (implying elasticities of output with respect to employment of less than one), which squares better with economic theory than do results of several other macro-econometric models. 28/

The agricultural labor absorption function was estimated from a basically pre-high yielding variety set of data. The data problems relevant here were mentioned earlier. We nevertheless might use this function to estimate the macro employment implications of the high yielding varieties, on the justification that our micro results indicate that overall use of labor on rice farms is not materially affected by the high yielding

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26/ This rough type of calculation is used by H. T. Oshima, "Labor Absorption in East and Southeast Asia: A Summary with Interpretation of Postwar Experience," Malayan Economic Review, 1971 (forthcoming).

27/ Williamson, op. cit.

28/ M. Nerlove, "Notes on the Production and Derived Demand Relations Included in Macro-Econometric Models," International Economic Reviews, Vol. 8, No. 2, June 1967, pp. 223-242.

varieties. The farm surveys indicate a small increase in total labor requirements, but a significant change in the distributions of labor use according to the categories hired/non-hired and according to agricultural activity. We represent the contribution of the high yielding varieties by means of the expected increase in the growth rate of agricultural value-added after 1968, and compute the induced agricultural employment from the estimated labor absorption function.

(1) Agricultural value-added in 1967 prices rose by 4.4 percent in 1969 and by 4.9 percent in 1970. If we assume a 4.5 percent per annum growth rate over a five-year period beginning 1969, then cet. par., an annual increase in agricultural employment by 3.7 or 3.8 percent will be induced. But since this is the same as the growth rate of value-added in agriculture in the past, the estimated labor absorption rate is very conservative.

(2) The current four-year economic plan (Fiscal 71/72 to Fiscal 74/75) has as its (preliminary) target a rise in agricultural value-added by 5.3 percent per annum. At this rate, which is judgmentally feasible, agricultural employment would increase, cet. par., by 4.4 to 4.5 percent per annum. Compare the average annual growth rates over 1956-68 of the national series for labor force and employment:

	May series	October series
Labor force	3.9 %	2.7 %
Employment	4.0 %	2.5 %

Taking the average of the growth rates in the May and October sets as projected rates for later years, we would then conclude that labor absorption in agriculture could be large enough to prevent a further fall in the proportion of the employed in agriculture, if agricultural wages were not to change.

Recent data on wages (undeflated) of plowmen, planters and harvesters are shown in Table 13. They indicate a sluggishness in agricultural wage rates, except for 1970. The increase in the last year can be definitely attributed to the June 1970 ammendment to the minimum wage law, which raised minimum daily agricultural wages from ₱3.50 (set in August 1963 under the Agricultural Land Reform Code) to ₱4.75. The presence of minimum wage legislation rationalizes to some extent the assumption that wage levels are predetermined. The conclusion of the previous paragraph thus rests on the premise that agricultural wages maintain their lack of trend after the step taken in 1970.

CONCLUSIONS

One must use caution in generalizing the Philippine experience to the rest of Asia. However, with the rapid increase in the use of high yielding varieties to more than fifty percent of the total rice area, it is possible to reach certain tentative conclusions concerning the potentia effect of the new technology on production and employment.

There can be little question that the introduction of high yieldi varieties has had a significant impact upon yields at the national level. However, while the yield gains have been dramatic on some farms and in som areas, for the nation as a whole, they are far more modest. The analysis of farm data shows that despite the shift to high yielding varieties many farmers are not achieving what would appear to be the yield potential. The constraining factors are not yet clearly identified. The high growth in output currently being achieved combines the impact of higher yields and expanded irrigation. Maintaining output at a pace with increased demand for rice will require continued progress in both directions.

Farm level analysis of employment effects indicate that even in those regions where mechanization has progressed, per hectare labor requirements, especially for hired labor, have increased. A high level of mechanization is not a precondition for the successful introduction of the new seed-fertilizer technology. On the other hand, higher farm income generated by the new technology may tend to increase the rate of mechanization. Studies indicating the secondary effects of the new technology on employment in the farm and non-farm sectors are unfortunately not available. 29/ In those areas where new varieties have brought substantia higher yields, there is a noticeable increase in the pace of non-farm activity. Employment also may have changed as a result of major shifts occurring in land use in agriculture. Increases in production and employment in the rice sector are taking place on a declining land base, as marginal rice land has been released to other uses. On balance it would appear that the unmeasured secondary effects should have a positive influence on employment and labor absorption.

Statistics to show the recent trend in national agricultural employment are not yet available. The employment-output (value-added) elasticity for Philippine agriculture is estimated to be 0.7. Assuming that the employment output elasticity is not materially affected by the new technology in rice and wage rates do not rise, maintaining the past level of labor absorption would require a growth in agricultural value-added of 4.5 percent or better.

29/ There is only one study under way that we are aware of in this area. See, Arthur Gibbs, Jr., "A Note: Defining the Non-Farm Employment Question," The Philippine Agriculturist, Vol. VII, February-March 1969, pp. 602-613.

Table 1. Percent of lowland rice planted to high yielding varieties on irrigated and rainfed lands in the Philippines, 1967-68 to 1970-71.

	Crop Year			
	1967-68	1968-69	1969-70	1970-71
	(% of area in HYV's)			
<u>Total lowland</u>				
Northern Luzon	17	29	37	47
Central Luzon	16	32	37	46
Southern Luzon	30	55	67	71
Visayas	18	33	46	51
Mindanao	30	53	64	72
<u>Philippines</u>				
Total lowland	22	41	50	57
Irrigated	33	54	61	67
Rainfed	13	28	39	45

Source: Based on data from the Bureau of Agricultural Economics, Department of Agriculture and Natural Resources, Government of the Philippines. Includes IRRI, UPCA, and BPI varieties.

Table 2. Production, area, and yield of rough rice and percent of crop area irrigated, Philippines, 1948/50 to 1969/71.

Three-year period	Production 1000 m.t. (rough rice)	Crop area	Cultivated area	Upland area	Percent crop area irrigated	Yield m.t./ha (rough rice)
		--- 1000 ha	------			
1948/50	2446	2135	1900	514	19[a/]	1.15
1951/53	2864	2458	2268	621	n.a.	1.17
1954/56	3220	2681	2435	687	22[b/]	1.20
1957/59	3411	3083	2748	739	24[c/]	1.11
1960/62	3785	3228	2757	683	28	1.17
1963/65	3934	3150	2675	653	31	1.25
1966/68	4242	3170	n.a.	511	38	1.34
1969/71	4968	3186	n.a.	406	45	1.56

n.a. Data not available.

a/ Irrigated area available only for crop year 1947-48.

b/ Irrigated area available only for crop year 1955-56.

c/ Irrigated area available only for crop year 1958-59.

Source of basic data: Bureau of Agricultural Economics, Department of Agriculture and Natural Resources, Government of the Philippines.

Table 3. Annual growth in rice production and contributions of change in yield per hectare, irrigated area and non-irrigated area to growth for selected time periods and regions in the Philippines from crop years 1948 to 1971.[a]

	Production growth rate (% per annum)	Percent of production growth due to change in[b]			
		Yield per hectare	Irrigated crop area	Non-irrigated crop area	Total
		%			
Philippines					
1948-1960	4.6	31	36	33	100
1961-1964/66	1.7	136	-6	-30	100
1964/66-1969/71	4.6	60	82	-42	100
Regional 1964/66 to 1969/71					
Northern Luzon	4.6	44	149	-93	100
Central Luzon	6.8	28	72	0	100
Southern Luzon	3.3	46	125	-71	100
Visayas	5.4	84	27	-11	100
Mindanao	2.4	121	97	-118	100

a/ Crop year 1948 refers to the period from July 1947 to June 1948 and similarly for all years.

b/ The formula used to determine the sources of production growth is as follows: $Q_1 - Q_0 = (Y_{i1} - Y_{i0})A_{i1} + (Y_{r1} - Y_{r0})A_{r1} + (Y_{u1} - Y_{u0})A_{u1} + (A_{i1} - A_{i0})Y_{i0} + (A_{r1} - A_{r0})Y_{r0} + (A_{u1} - A_{u0})Y_{u0}$, where Q denotes total production, Y the yield per hectare, A the effective crop area harvested, "i" irrigated lowland area, "r" rainfed lowland area, "u" upland area and subscripts 0 and 1 denote the beginning and end of the period analyzed. In this formula the first three terms $(Y_{i1} - Y_{i0})A_{i1} + (Y_{r1} - Y_{r0})A_{r1} + (Y_{u1} - Y_{u0})A_{u1}$ denote the combined effect of yield increases on each land type, the fourth term $(A_{i1} - A_{i0})Y_{i0}$ denotes the effect of changes in irrigated crop area and the last two terms $(A_{r1} - A_{r0})Y_{r0} + (A_{u1} - A_{u0})Y_{u0}$ denote the combined effect of changes in rainfed lowland and upland crop area.

Sources of basic data: Data for crop years 1948 and 1960 from the Census of Agriculture 1948 and 1960, respectively; Data for crop year 1961 and 3-year averages 1964/66 and 1968/71 from Bureau of Agricultural Economics, Department of Agriculture and Natural Resources (The 1960/62 3-year average could not be used since comparable data by land type are not available).

Table 4. Three year averages of yield per hectare by land type, region and variety (m.t./ha), Philippines and five regions.

	1964/66 Average	1969/71 Average	1969/71 Local	1969/71 HYV*	100 x (HYV-LV)/LV (percent)
Irrigated					
Philippines	1.70	1.92	1.79	1.99	11
N. Luzon	1.89	1.88	1.67	2.10	25
C. Luzon	2.20	2.31	2.15	2.48	16
S. Luzon	1.72	1.81	1.63	1.89	16
Visayas	1.21	1.63	1.61	1.65	2
Mindanao	1.30	1.78	1.50	1.87	24
Rainfed Lowland					
Philippines	1.21	1.39	1.37	1.44	5
N. Luzon	1.06	1.44	1.41	1.55	10
C. Luzon	1.70	1.92	1.80	2.21	23
S. Luzon	1.17	1.20	1.21	1.20	-1
Visayas	1.06	1.25	1.21	1.32	9
Mindanao	1.16	1.22	1.16	1.27	9
Upland					
Philippines	0.77	0.93			
Luzon	0.75	1.00			
Visayas	0.55	0.73			
Mindanao	0.88	0.94			

Source: Based on data from Bureau of Agricultural Economics, Department of Agriculture and Natural Resources, Government of the Philippines.

* Includes IRRI, UPCA and BPI varieties.

Table 5. Percent area planted to HYV's, nitrogen applied and grain yield per hectare by location and by adoption o f HYV, Laguna wet season 1966 and 1969.

Category	No. farms	Nitrogen applied (kg/ha) 1966	Nitrogen applied (kg/ha) 1969	Grain Yield (P/ha) 1966	Grain Yield (P/ha) 1969
Location					
Biñan	45	8	47	1.9	2.5
Cabuyao	56	16	51	2.2	4.3
Calamba	51	22	44	2.9	4.0
Adoption of HYV 1969					
Full adopters	83	14	49	2.3	3.8
Partial adopters	49	17	46	2.5	3.5
Non-adopters	20	19	45	2.5	2.8
Full adopters by location 1969					
Biñan	31	8	52	2.0	2.9
Cabuyao	29	15	44	2.1	4.6
Calamba	23	21	51	2.9	4.3

Table 8. Methods of weeding used by 153 farmers in Laguna survey and by 76 farmers in Central Luzon-Laguna surveys, 1966 and 1970 wet seasons.

Method of weed control	Farmers (%)			
	Laguna		Central Luzon-Laguna	
	1966	1970	1966	1970
Chemical only	25	0	4	3
Hand only	8	1	53	37
Rotary weeder only	6	1	4	0
Chem. & hand	25	15	9	28
Chem. & rotary weeder	22	11	0	1
Rotary weeder & hand	1	3	1	7
Chem. & hand & rotary weeder	13	69	4	9
No weeding	0	0	25	16

Table 9. Household population by labor force and employment status: May 1957 to May 1968
(In thousands)

Year	In the labor force	Total employed (fully and partially)	Employed in agriculture a/	Employed in non-agricultural industries b/	Totally unemployed
1957	8,922	8,149	4,938	3,211	773
1958	9,659	8,782	5,325	3,457	878
1959	9,575	8,836	5,450	3,387	739
1960 c/	9,920	9,111	5,533	3,577	808
1961	10,277	9,395	5,617	3,778	883
1962	10,692	9,680	5,910	3,770	1,012
1963	11,187	10,315	6,131	4,184	871
1964	11,296	10,572	6,188	4,384	724
1965	11,491	10,543	6,052 (31)	4,491	947
1966	11,886	11,032	6,275 (245)	4,757	854
1967	13,274	12,185	6,993 (31)	5,192	1,089
1968	13,534	12,481	7,202 (65)	5,280	1,053

a/ Standard errors of estimate in parentheses where available.

b/ Includes persons for whom no industry was reported.

c/ No May survey was taken in 1960. Figures for this year are based on the annual geometric growth rate for the period 1959-1961 and applied on 1959 figures.

Sources: Mijares and Tidalgo (1971), Table 8.

Table 10. Household population by labor force and employment status: October 1956 to October 1968 (In thousands)

Year	In the labor force	Total employed (fully and partially)	Employed in agriculture a/	Employed in non-agricultural industries b/	Totally employed
PHILIPPINES					
1956	8,561	7,702	4,548	3,154	859
1957	8,829	8,199	4,997	3,202	630
1958	8,976	8,329	5,276	3,052	647
1959	9,116	8,575	5,298	3,278	540
1960	9,116	8,539	5,224	3,315	577
1961	9,713	9,095	5,514	3,580	618
1962	10,266	9,603	5,898	3,706	662
1963	10,233	9,764	5,779	3,985	469
1964 c/	10,485	9,927	5,752	4,176	558
1965	10,764	10,101	5,725 (26)	4,376	663
1966	11,757	10,936	6,290 (85)	4,646	821
1967	11,776	10,867	6,330 (43)	4,537	909
1968	11,371	10,471	5,631 (63)	4,839	900

a/ Standard errors in parethenses where available.

b/ Includes persons for whom no industry was reported.

c/ No October survey was taken in 1964. Figures for this year are based on the annual geometric growth rates for the period 1963-1965 and applied on 1963 figures.

Source: Mijares and Tidalgo (1971), Table 9.

Table 11. Employment in agriculture and on rice and corn farms, by sex 1966 - 1968 (In thousands)

		In Agriculture		On Rice and Corn Farms	
		May	October	May	October
1966	Total	6275	6290	4355	4328
	Male	4857	4767	3285	3169
	Female	1419	1523	1070	1159
1967	Total	6993	6330	4685	4349
	Male	5315	4726	3497	3140
	Female	1678	1606	1188	1209
1968	Total	7202	5631	4905	3959
	Male	5339	4469	3542	3065
	Female	1863	1162	1363	894

Source: Mijares and Tidalgo (1971), Tables 46 and 47.

Table 12. Elasticities at the means of sectoral employment with respect to the sectoral wage rate, value-added, and price level.

	Wage	Value-added	Price level	$\bar{R}^2$ of source regression
1. Agriculture, fishing and forestry	-0.14**	0.70		.90
2. Mining and Quarrying	-3.25*a/	2.57		.55
3. Manufacturing		0.54		.92
4. Construction	-0.48**a/	0.97	1.65b/	.89
				.64
5. Transport, storage, communications and Utilities	-0.38		2.20	.93
	-0.23*	1.19		.94
6. Commerce	-0.66	1.35		.93
	-0.89		1.92	.96
7. Services		1.08		.95

** Underlying coefficient not significant at the 10% level.
* Significant at the 10% level. Unstarred figures are from coefficients significant at the 5% level or better.

a/With respect to the unskilled wage rate in industry as a whole.

b/With respect to the general price level.

Table 13. Average daily wage rates (no meal provided) on palay farms, Philippines, 1966-1971. (In pesos)

Average of 2nd & 3rd quarters	Plowing	Planting	Average of 4th & 1st quarters	Harvesting
1966	4.32	3.22	1965/66	3.61
1967	4.66	2.84	1966/67	4.12
1968	4.65	2.97	1967/68	3.68
1969	4.81	2.60	1968/69	3.17
1970	5.13	3.13	1969/70	3.32
			1970/71	4.51

Source of basic data: Bureau of Agricultural Economics.

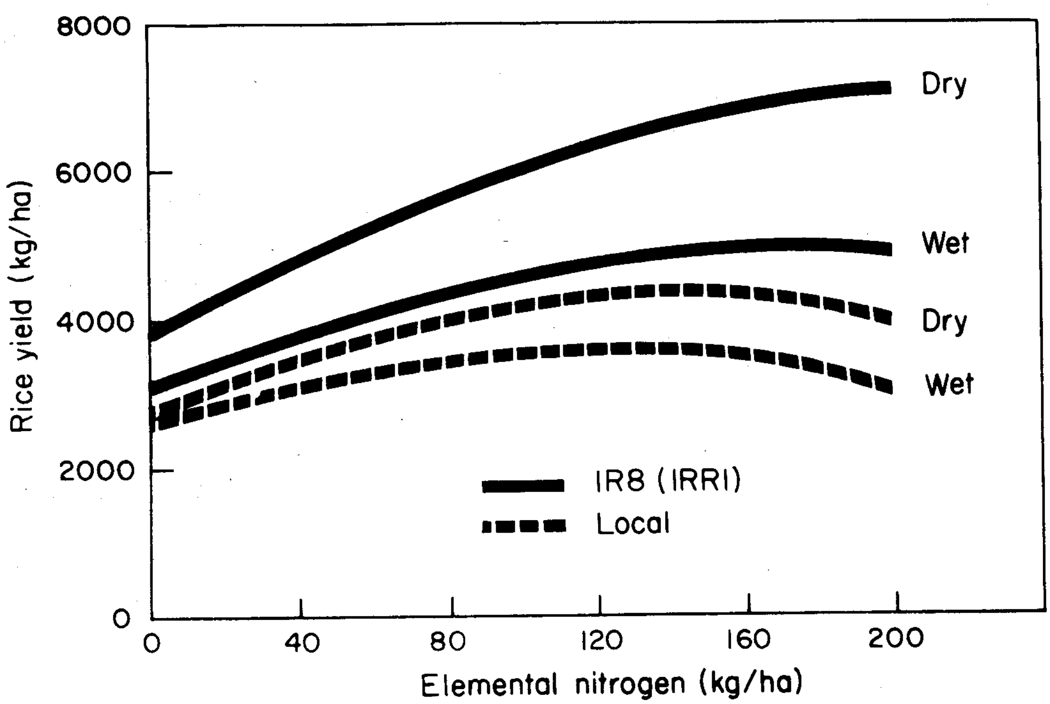

Fig. 1. Variability in yield response of rice to nitrogen by variety and season. India, 1968. Based on experiments of All India Coordinated Rice Improvement Project.

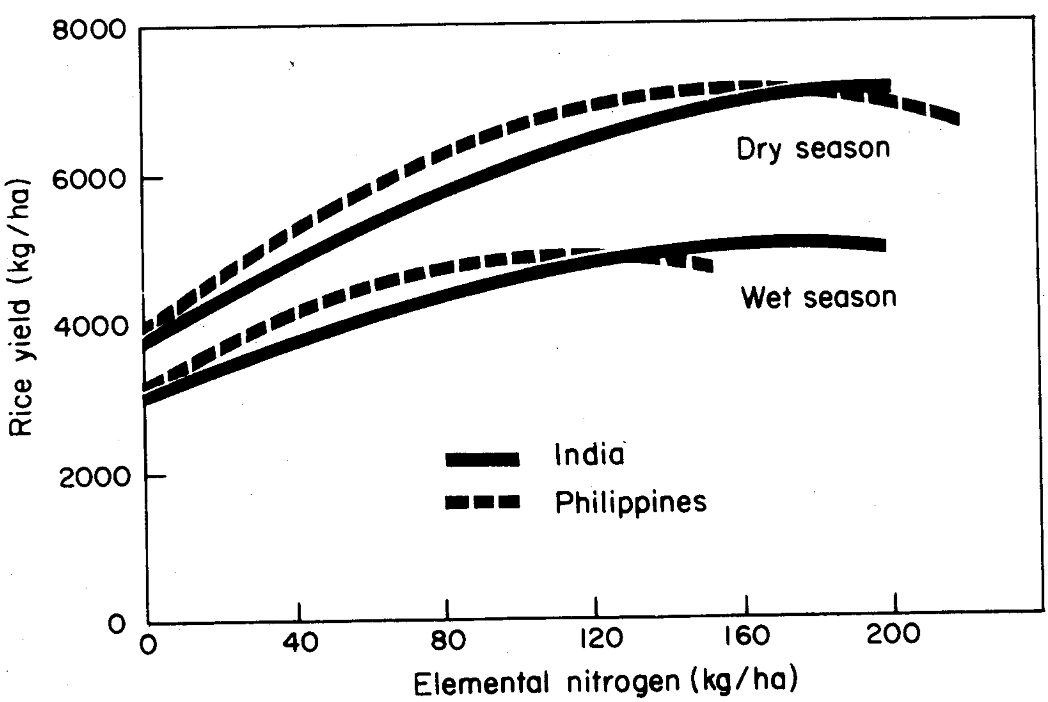

Fig. 2. Variability in yield response of IR8 variety to nitrogen by location and season. India, 1968 (19 locations) and Maligaya Rice Experiment Station in Central Luzon, Philippines (average of 1966, 1967, and 1968).

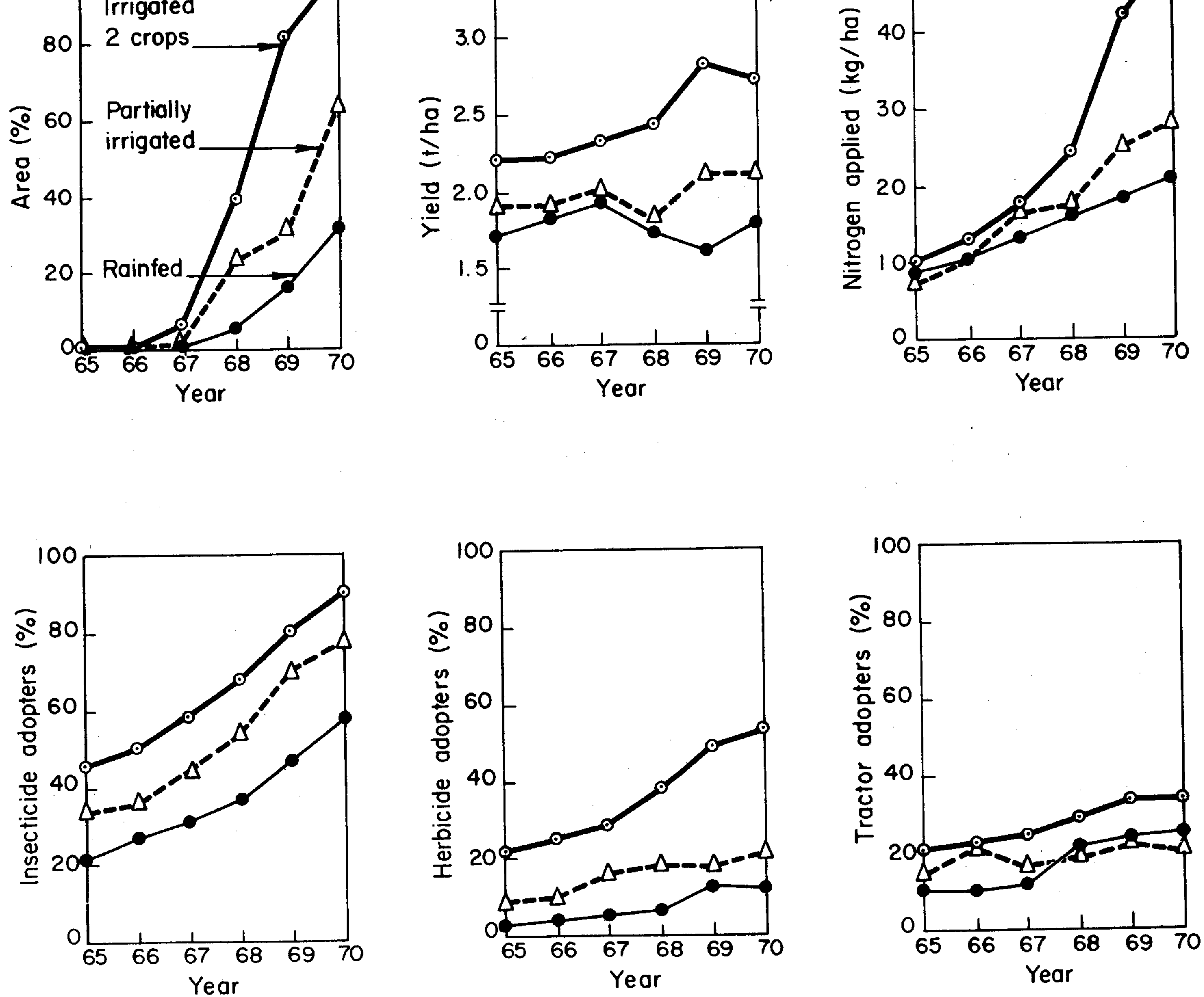

Fig. 3. Proportion of area planted to high-yielding varieties and yield and input use for all varieties by land type for the wet season, Gapan, Nueva Ecija.