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HYV IN THE PHILIPPINES:
PROGRESS OF THE SEED-FERTILIZER REVOLUTION

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HYV IN THE PHILIPPINES:
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Summary

About half of the lowland rice area in the Philippines was planted to high yielding varieties (HYV) in the crop year 1969-70. Yields averaged 20 percent higher for HYV than for other varieties in the irrigated area and about 10 percent higher in the non-irrigated lowlands. However, one-fifth of the HYV growers in the irrigated area obtained high yields--more than 75 cavans (3.3 metric tons) per hectare and averaged 97 cavans (4.3 tons) per hectare, or nearly twice the mean for the whole group.

The farm data are stratified random samples from Bureau of Agricultural Economics (BAECON) regular crop report, the Integrated Agricultural Survey (IAS). They include (1) a detailed analysis of 2,100 cases from the two seasons of the 1969-70 crop year, and (2) a summary analysis of 10,000 cases from the wet season (July-Dec.) 1971. The International Rice Research Institute (IRRI) data are from a new comprehensive summary of fertilizer response variety trials conducted by IRRI over a period of years (1966-71).

In the irrigated areas in the principal (wet) season, one-third of the farmers growing HYV used no commercial fertilizer and one-third used no chemicals for weed, pest, and disease control. Those using fertilizer applied an average of 32 kilograms per hectare of nitrogen plus phosphorus for both HYV and non-HYV growers, about one-third the recommended rate for irrigated HYV.

The calculated yield response for HYV growers was lower than the widely used UNDP fertilizer trial response in the Philippines (average of wet and dry seasons), but about the same as in International Rice Research Institute (IRRI) trials for the wet season, although the level of yields in the IRRI trials was about twice as high. In the dry season, the level of yields and the response to fertilizer was about the same as the wet season average for all farmers growing HYV on irrigated land, but both level and yield response for IRRI were about twice as high as for farmers.

In fact, the dry season IRRI trials had higher yield than the UNDP-FAO Philippine trials through most of the range of fertilizer application as well as greater response to added increments of fertilizer. These high yields and high response to fertilizer during the dry season provide the great contrast between HYV trials and what average farmers have obtained and have been widely publicized. The farmers average level of yields and response to fertilizer were similar, however, to IRRI observed farmers fields with moderate water stress (T. Wickham), a condition which is common in the dry season, and perhaps typical. Farmers reported paying prices appreciably higher than published market prices for fertilizer. As a consequence, the calculated profitability for fertilizer usage and the optimum rate were lower than most previous estimates. The observed fact that most farmers are <u>not</u> following extension service recommendations may reflect a true lower fertilizer-yield response under farm conditions than under the conditions assumed when the recommendations were formulated. In fact, new analyses of IRRI experimental results

indicate that the optimum level of fertilizer usage based on return-cost considerations in the wet season is lower than that previously assumed. This analysis combined with the new summary of IRRI data suggests that those farmers who use fertilizer on the average have come fairly close to an optimum usage. Differences in fertilizer usage accounted for little of the variation in rice yields; more research is needed to find out the constraints that are preventing fuller exploitation of the yield potential of HYV.

The most obvious explanation of the difference between yields at IRRI and on farmers fields is that farmers lack the control that the experimental plots have for pest and diseases, water and timing of operations. And it is not surprising that IRRI does not know exactly why experimental results are not being duplicated in farmers fields--for they have not had extension activities as a major aim--but such research is now underway. Also, IRRI spares no cost to ensure controlled conditions, which may not be economical or even possible for farmers.

Findings of this research are of particular importance given current world-wide shortages and very high prices of fertilizer and other petroleum-based chemicals. Factors other than fertilizer use account for (50 to 80) percent of the variation between farms in yields per hectare, and factors other than (1) fertilizer and (2) other chemicals (pesticides and herbicides) combined account for (40 to 70) percent. If the more important "other" factors can be identified by new surveys or experimental results, then increased emphasis can be placed on these in farmer recommendations so that yields can be maintained or increased despite the tight world supply-demand situation for fertilizer and certain other chemicals.

Introduction

The Philippines has played an important role in the introduction of rice high yielding varieties (HYV) in Southeastern and Southern Asia. In the summaries of international comparisons, the Philippines leads the list in the proportion of rice area in HYV. In Dalrymple's summary for 1970/71, the Philippines had 50 percent in HYV, followed by W. Pakistan with 42 percent, and in total area in HYV was second only to India.[1/] In 1971/72, HYV had spread to 63 percent of all lowland paddy area and to 73 percent of the irrigated portion. The location of the International Rice Research Institute (IRRI) in the Philippines has facilitated the introduction of HYV and the adoption of the appropriate technology.

This paper is an analysis of yields obtained from HYV and non-HYV (1) by farmers in the Philippines with special reference to fertilizer application and response in the irrigated paddy lands, and (2) by experiments and farm trials. Major objectives are a description of fertilizer response of HYV in the Philippines, comparison with other varieties, contribution of HYV to rice production, and a perspective on the exploitation of the potential of major technological advances.

The study began with an analysis of farmers' experience and gains. Initial comparison and contrast with IRRI results were puzzling. Despite the great difference in the level of yields obtained, similarities in the response to fertilizer began to appear, at first for the principal (wet)

1/ "Imports and Plantings of HYV of Wheat and Rice in Less Developed Nations," FEDR-14, February 1972, USDA, p. 51.

season, and then from the water-stress experiments, for the dry season. The decision was made to combine the IRRI information on fertilizer response with the results of the BAECON Integrated Agricultural Survey to trace the development of HYV in the Philippines.

HYV and TRAD Yields -- 5-Year Record

Two questions are often asked about HYV: How much do yields exceed other varieties? How much did adoption of HYV add to total production?

Regular surveys (IAS) based on large stratified samples by BAECON make possible calculations that provide reasonably good answers for the Philippines.

First, how much higher yields were obtained by HYV growers than traditional (TRAD) growers? For the Philippines as a whole, the average yield per ha. of HYV exceeded TRAD by 30 to 35 percent over the past few years (1968-72) for which IAS data are available. This gross difference is sometimes referred to as the yield gain attributable to HYV. But an adjustment for the varying proportions of HYV and TRAD on upland, irrigated lowland, and rainfed lowland provides a better basis for comparison. If upland rice is omitted from the calculation, since HYV is of no consequence there, then the average difference in yield between HYV and TRAD drops to 19 percent for all lowland (see Appendix table 3, last column). Since HYV is better adapted for irrigated land, and a higher proportion is grown under irrigation, it is logical to make separate calculations for irrigated and for rainfed lowland. Such calculations show that HYV out-yielded TRAD by an average of about 10 percent in the past 5 years, if the proportions

irrigated are standardized for the two variety types. For the 5 year period the average differences were as follows:

1968 - 17 percent	1971 - 4 percent
1969 - 9 percent	1972 - 14 percent
1970 - 9 percent	

The average differential for the 5-year period of HYV over TRAD yield was 14 percent for the irrigated area and 2.5 percent for rainfed lowland. It is often said that the differences have declined over the years. As shown in the text table the difference was greater in 1968 than in any other year, but there is no subsequent trend, merely fluctuations. These comparisons make no adjustment except for irrigation. Whereas it might be expected that they overstate yield differences because HYV would be expected to be adopted on the more productive areas, there is some evidence that the comparisons may somewhat understate yield differences. A detailed regression analysis of a sample of the 1969-70 data showed differences of about 20 percent in favor of HYV for the irrigated area, about 10 percent for the 1st semester rainfed, and no difference for the 2nd semester rainfed, or a weighted average of 13 percent more as compared with the 9 percent average reported above. In any case the range of 9 to 13 percent difference between HYV and TRAD is strikingly smaller than the usual estimates of 30 to 35 percent. The calculations are shown in a set of tables in the Appendix.

The second question is how much has production been increased by the adoption of HYV in the Philippines. Again using the BAECON's IAS data, the average of 30 to 35 percent higher yield for all HYV applied to the adoption proportion gives a difference of 12 percent. However, if the

differences are calculated separately for irrigated, rainfed (lowland) and upland, the 5-year average is 4.3 percent higher production attributable to the higher yield of HYV over TRAD (see Appendix table 2). It should be pointed out that yields of traditional varieties have shown some increase since the HYV were introduced about 1967. Some of the rise may be attributable to a change in the method of estimating yield introduced in 1970. Nevertheless, these considerably smaller yield differences between HYV and TRAD varieties than experimental data, most farm trials and demonstrations, and intuitive estimates not based on systematic farm surveys appear to be the better estimates of the average differences in yield obtained by Philippine farmers adopting HYV as compared with those sticking to traditional varieties.

Data Analyzed in This Report

Two types of data are analyzed in this report. They are (1) the general surveys of farmers conducted by the BAECON, and (2) fertilizer response experiments conducted by IRRI including supervised trials in farmers' fields; these are compared with data from detailed observation by IRRI without supervision of farms with varying types of irrigation (water-stress).

The survey data of the BAECON are drawn from the two crop years 1969-70 and 1971-72. For the earlier year a subsample of 2100 farms was drawn from the Bureau's Integrated Agricultural Survey (i.e. the official crop report). This was a good "normal" year in the Philippines, and more input information was collected than in other years. More limited data from a larger sample in 1971-72 provide comparable summary estimates for the wet season.

The IRRI fertilizer response experiments for HYV and traditional varieties (TRAD) are located in the experiment stations (Los Banos and other stations in the Philippines). The data shown here are from the new comprehensive analysis of all fertilizer response variety trials for released varieties in the various IRRI stations in the Philippines for the period 1966-71. Saowance Pisithpun in her unpublished M.S. thesis at Los Banos examined about 1000 trials.2/ The summary relationships exclude trials that gave results contrary to theoretical expectations such as those showing increasing returns throughout or no maximum yield.

The trials in farmers' (or a farmer's) fields in Laguna are rather closely supervised by the Agronomy Department of IRRI, so that the results are not much different from IRRI experiments, although the management used may be within reach of many farmers with good irrigation. The water-stress studies are of unsupervised farms, and they were selected to include less-than-adequate irrigation conditions that produce water stress.

This combination of experiments, farm trials, observations of selected farms, and general sample surveys provides a broad range of yield-fertilizer response information whose interpretation turns out to be surprisingly consistent. For those analyses that relate to individual farms, error terms are much larger than the variation explained by the factors for which data were available from the surveys. For the controlled experiments, error terms of (20 percent) or so were common. Research currently is underway to isolate factors now included in the error terms, and further

2/ "Fertilizer Response of Rice under Varying Environment and Management Practices." U.P. Los Banos, October 1973.

research and surveys in this area are urgently needed. A major result of the present study is to indicate the importance of such research.

The procedure that is followed here is to present the results of the general survey data of BAECON, make summary comparisons with IRRI experiments and farm trials, and then refer to the water-stress results.

General Comments on Yields

The Integrated Agricultural Survey (IAS) sample data for 1969-70 was broken down into 1st semester or wet season (July-December 1969); 2nd semester or dry season (January-June 1970); irrigated and rainfed; HYV and traditional varieties. There were enough cases in each of these groups except rainfed in the second semester to permit a statistical analysis. Irrigated areas average from 500 to 700 kgs. higher yield than rainfed areas. Within the irrigated area, HYV averages 350 to 400 kgs. higher than other varieties whereas in the rainfed areas, HYV yields are about 190 kgs. higher in the wet season and about equal to other varieties in the dry season. See Table 1 for averages and medians, and Figures 1 and 2 for yield distributions.

In contrast to the International Rice Research Institute experience and some farm trials and demonstrations, wet season yields for irrigated varieties in the IAS sample average about 130 kgs. higher than in the dry season. Finally, upland yields average 450 kgs. less than rainfed lowland yields.

Other Yield Comparisons

The difference between HYV and traditional variety yields reported here from farm surveys are smaller than most comparisons, especially those reporting on experiments or supervised farm trials. However, a few surveys of farms have found results similar to those reported here. P. C. Manuel and M. P. Lopez 3/ of UPCA found small differences in yields of HYV and traditional varieties for the season 1967-68 in Laguna and Rizal, leading provinces in adoption of HYV's.

L. A. Paulino and L. A. Trinidad 4/ of the Bureau of Agricultural Economics using the BAECON data for crop years 1968 and 1969 found that average yield on irrigated land for the IR series was 1890 kgs. per ha. vs. 1630 for traditional varieties, an advantage of 260 kgs. Some of the farm comparisons of HYV and traditional by R. Barker and associates of IRRI have also shown small differences and poor response to fertilizer5/.

Yield Distribution Characteristics

In general, the yield distributions are skewed to the right, like incomes with the median smaller than the mean, as shown in Table 1. For irrigated paddy production the adoption of HYV's leads to a more normal distribution. For rainfed or non-irrigated lowland paddy the shift is a further skewing to the right.

3/ "Productivity of Farms Using Traditional and Improved Rice Varieties in Rizal and Laguna," pp. 3-1 to 3-20. Seminar on Economics of Rice Production in the Philippines, UPCA-IRRI, 1969.

4/ "The Shift to New Rice Varieties in the Philippines." pp. 1-1 to 1-20 in Seminar UPCA-IRRI, op. cit.

5/ "The Probable Impact of the Seed-Fertilizer Revolution on Grain Production and on Farm Labor Requirements." Mimeo. Paper prepared for Stanford University Conference, December 1971. (The preliminary paper is more explicit than the final published one.)

Rather wide variation in yields around the mean were reported and the size of farm and area harvested was small. (See figs. 3, 4, and 5). There is a reporting problem for area of farm and area harvested which relates to the unit in which land is measured. Most of the farms are less than four hectares in size. As a result there is a tendency to report farm size at standard reference points such as 1/2, 1, 1-1/2, 2, 2-1/2, and 3 hectares rather than points in between. In the sample used over 2/3 of the farmers reported harvested area on these points. The use of a smaller unit such as dekars (1/10 ha.) would permit more accurate determination of yields. This rounding problem increases the variation of calculated yields and possibly biases them if there is systematic under or over reporting 5/. In the regression analysis which follows there is little which can be done to account for this source of variation. It may be large and may also tend to obscure any true relationships.

Multiple Regression Analysis

A regression analysis was run with yield as the dependent variable. The numerical independent variables were fertilizer (kgs.), chemicals (pesos) and irrigation fee (pesos). In addition dummy variables were included for region, size of farm, tenure, and type of irrigation.

5/ K. A. Gomez and B. T. Onate in an analysis of Laguna data estimated that BAECON's method of yield estimates gave 5 percent overestimate of area, and hence under-estimation of yield for the year 1967. A revised estimation procedure was started in 1970 by BAECON, and it is not known if the earlier criticism is applicable to the current estimating procedure. "Response Bias in the Collection of Rice Statistics." The Philippine Agriculturist, Vol. III, Feb-Mar., 1969, pp. 602-613.

The General Form of the Regression Function

Yield Paddy Kg./ha.	= F	Fertilizer Kg. N+P/ha.	Chemical expenditures Pesos/ha.	Irrigation fee Pesos/ha.	Dummy variables region, size of farm, tenure type irrigation

For fertilizer both a linear and a quadratic term are fitted:

$$y = a + b_1 (X_F) - b_2 (X_F)^2 + b_3 (X_c) + \dots .$$

where Y = yield paddy in kgs./ha.

X_F = fertilizer in kgs./ha. of Nitrogen + Phosphorus

X_c = chemicals in pesos/ha.

a = constant

$b_1, b_2, \& b_3$ = coefficients to be fitted

Quadratic terms were tried for chemicals and interaction terms for fertilizer and chemicals, but they were statistically insignificant and unstable. With the exception of fertilizer, the discussion that follows deals with the coefficients in the final equation, shown in table 2.

A stepwise program was used, with variables entering the calculation if the standard error was no larger than the regression coefficient (t=1), and once they entered they stayed in through subsequent steps even if the t-value fell below.

Fertilizer Response Based on the Regression Analysis

The importance of fertilizer response of HYV has been stressed in experiments and demonstrations. The simple relationship between yield and fertilizer application per hectare for HYV irrigated in the first semester for the IAS sample is shown in the scatter diagram figure 6. The correlation between yield and fertilizer is not high (r^2=.12), and only a small proportion of the variation in yield is explained by

variation in fertilizer use, even with the addition of the quadratic term (i.e. fertilizer squared). Nevertheless, these two terms account for more than half of the explained variation in yield.

The second input available from the sample is expenditure for chemicals to control weeds, pests, and diseases (fig. 7). Chemical expenditure may not be as satisfactory an independent variable affecting yield as fertilizer, since the use of more chemicals might reflect a more serious control problem instead of giving added control.

For herbicides there are specific recommendations, and relatively low cost herbicides are reported to give good control under good moisture conditions, if directions are followed. Nevertheless, herbicides are little used on Philippine farms. For pesticides, generally, i.e. control of all types of pests and diseases, the situation is more complicated, and there are no general recommendations--it depends on the incidence of the pest or disease. One of the major thrusts of IRRI is to produce resistant strains or seed varieties.

These caveats notwithstanding, chemical expenditures were hypothesized as being an index of the attempt made to control weeds and pests other than that made by cultivation, hand weeding practices, and variety selection. After fertilizer, chemicals was the most important variable in explaining variations in yield, and the positive regression coefficient was statistically significant (t=4). However, the expenditures made were rather small--the average was 6 pesos (or about $1.00) per hectare, and hence represents a very slight control effort. Since the use of HYV's and fertilizer ordinarily intensify the weed, pest, and disease problems, and the

humid, tropical conditions in the Philippines have a similar influence, weed, pest and disease control are important needs for palay farmers. IRRI is giving attention to what can be done about these problems on the basis of economically profitable practices for farmers.

Fertility and climatic conditions are important influences upon yield. They are represented in the regression analysis only by the weak proxy of location by region. Although yields vary considerably by regions, the independent effect of region, other than that associated with irrigation, variety type, and fertilizer, was rather limited in the irrigated HYV regression equation. The Central Luzon area was used as the standard. Three regions had higher yields (t-value greater than one)--Cagayan Valley, Bicol, and Southern and Western Mindanao--and the other five regions were not significantly different from Central Luzon.

Type of irrigation was tried, with negligible results. The one dominant type, stream diversion, made the results of other types of limited significance. The ownership of the irrigation system was a little more significant with government ownership associated with somewhat higher yields than cooperative or individual efforts. Irrigation fees were also of some influence, and directly related to yield. Size of farm was an inconclusive variable. Tenancy was likewise of limited influence upon yields.

Profitability Calculation

A common way to calculate how much fertilizer is profitable is to make use of a fertilizer response curve, and to relate this to the price ratio, using 2 to 2-1/2 to 1 as the appropriate return and allowing

for the harvesters' share. We have used 2-1/2 to 1, and not allowed for the harvesters' share which is equivalent to 2.1 to 1, including the harvesters' share. One side of the profit calculation is to determine what ratio of yield response will return 2.60 to 1 (see equation 1.1, Table 2). For the curve fitted for the wet season, irrigated HYV, this ratio is reached at a relatively low fertilizer application, (35 kgs./ha. of N+P), near the mean rate of usage in 1970 for those using fertilizer. Thus, the typical Filipino farmer using HYV on irrigated land in the wet season was about in equilibrium for fertilizer usage, given the relatively low yield-response to fertilizer.

An additional influence restricting the optimum fertilizer application is that farmers in this group reported paying an average of 1.75 pesos per kilogram of N+P, about one-third higher than the published market price for Central Luzon. The national average price received by farmers for palay (reported by BAECON) of 16 pesos per cavan or .36 pesos per kilogram was used in the calculation, giving a fertilizer (N+P) - palay price ratio of 4.86 to 1. This is less favorable for the farmer than the 4 to 1 ratio which has been calculated for the Philippines for recent years for nitrogen-palay (excepting those benefiting during the fertilizer subsidy period 1959-63).

TRADitional-Irrigated, Fertilizer Response

For the non-HYV, the regression results for fertilizer users (54 percent of the total) showed a yield response that was about three-fourth as large as for the HYV group. There was no indication of diminishing response as application increased, mainly because there were

few observations for heavy fertilizer usage. For reasons that are not clear, several of the dummy variables that were insignificant for HYV accounted for a significant part of the variation in TRAD yield. In addition to the numerical variables fertilizer and chemicals, two of the dummy location variables, Ilocos and E. Visayas had yields lower than C. Luzon. The larger size farms also had lower yields, especially the next to the largest size group. For the irrigation variables, those who reported inadequate systems had lower yields, the community systems were also lower, and pump systems had higher yield than gravity systems. Finally owners got significantly higher yields than tenants. With the contribution of these several variables, the variation in yield explained was twice as great as for the HYV group (R^2=.35 as compared with .17). See equation 2-4, Table 2.

HYV and TRAD Comparison Irrigated - Wet Season

In addition to the comparison of the regression equations for HYV and TRAD, irrigated in the wet season, the comparison of yield levels obtained by fertilizer application can be made from cross-section tabulation, as shown in figure 8 and table 3. By far the largest groups were those using no fertilizer--37 percent of the HYVs and 46 percent of the TRAD's. For these two groups HYV yields exceeded TRAD by 71 kgs. However, the HYV group had a substantial reduction (one-third lower) in the variation in yield.

Most of the HYV growers using fertilizer applied from 10 to 65 pesos (5 to 35 kg. N+P) fertilizer and these got reasonably good response, with

yields around 2600 kgs., well above the average of 2055 kgs. for those who used no fertilizer, and from 350 to 900 kgs. higher than the traditional groups using the same quantity of fertilizer. Above 65 pesos per hectare for fertilizer, gains from fertilizer use were erratic, although the HYV groups obtained higher yield than the TRAD groups.

In the second semester--it is not dry in all regions--over 2/5 of the HYV growers used no fertilizer, obtained appreciably higher yields (6 cavans, or 264 kgs.) than non-HYV growers using no fertilizer, and also had lower variation in yields. In short, this large group of adopters of HYV reduced risks and obtained marginal gains from the revolutionary potential of high response varieties. For the fertilizer users, so few in the TRAD group are included in the sample that no comparison between the HYV and the TRAD yield can be made. See table 3 for fragmentary data.

Wet and Dry Response Compared

For the dry season, the yield response to fertilizer for HYV was about the same as in the wet season. In the lower range of fertilizer usage up to 45 pesos (25 kg. N+P), wet season yields averaged about 450 kgs. higher than in the dry season, but for those using more fertilizer, and for the large groups using none, the differences in yields were small and erratic (see figure 9).

Technical Note

(These equations are shown in the summary dated November 1972). The curves we have for users only seem to be better than with the non-users included for the dry season, but the reverse is true for the wet season!

For the wet and dry seasons, the users only curves are nearly straight lines and very similar with respect to fertilizer response:

Semesters

1st $Y = 1891.2 + 10.030\ P_f + 22.854\ P_c - .0223\ (P_f)^2$, p. 51, 3rd run, 11/24/72

2nd $Y = 1806.3 + 10.940\ P_f + 3.867\ P_c - .0262\ (P_f)^2$, p. 188, 3rd run, 11/29/72

where P_f = fertilizer per ha. in pesos; P_c = chemicals per ha. in pesos, and Y = yield in kilograms.

If we take the simple regression, or 1st step, we get:

1st $Y = 2{,}254.6 + 6.594\ Pf$

2nd $Y = 1{,}958.5 + 6.573\ Pf$

again very similar, and with lower slope.

For the wet season, inclusion of all the variables and adding non-users raises the slope a bit, and adds some curvilinearity. For the dry season, the slope is reduced.

For traditional, 1st semester the best curve has a slope for fertilizer 3/4 as steep (7.5 vs. 10), but has no curvilinearity.

HYV and TRAD Comparison - Rainfed Lowland

For rainfed, 1st semester, the average yield increase for HYV over TRAD was 190 kgs. or 12 percent--from 1588 to 1778 kgs., although the median increase was only 141 kgs. or less than 10 percent. (See figure 10 and table 4). Partly, this reflected a limited change in technology. Over half (54 percent) of the HYV group used no fertilizer, which was a small shift from the TRAD group, 46 percent of whom used no fertilizer.

For the large number of the HYV group using no fertilizer, the yield at 1600 kgs. was only 124 kgs. higher than for the TRAD no-fertilizer group. For those using fertilizer, up to 45 pesos per hectare, i.e., up to about 30 kgs. N+P/ha., the HYV group obtained an average of around 2000 kg., or about 420 kg. more than the TRAD group using the same amount of fertilizer. Thus, this group of HYV growers, representing nearly half of the fertilizer users, got good fertilizer response, with yields more than 400 kg. higher than the no-fertilizer HYV group, as well as a similar differential over the TRAD group using the same amount of fertilizer. Of the other HYV fertilizer users, a little more than half the total used 45 or more pesos of fertilizer, but got relatively small increments in yield as compared with the light fertilizer users of the HYV group, or as compared with the TRAD group using the same amount of fertilizer.

Optimum Fertilization -- Private vs. Social

We have now compared HYV and TRAD irrigated in the wet season and in the dry season as well as in the wet season for rainfed lowland. All these are important parts of the Philippine rice picture. We have omitted only upland rice, where HYV and the new technology have not yet had an appreciable impact. We wish now to go back to pick up the story of irrigated HYV in the wet and dry season, and to discuss the fertilizer response and profitability in more detail. Since the aim is to generalize as much as is warranted, we will include additional data for comparative purposes. The first set is the widely used yield-fertilizer response curve for HYV from the UNDP-FAO trials over a period of years in the

Philippines. The single curve to be used here is the one for the Philippines, HYV, an average for the wet and dry season 6/. It is not available by seasons. The second is the summary of IRRI fertilizer-response trials which is available by seasons. The third is a later year of the farm survey (IAS) by BAECON--the wet season 1971-72 for the Philippines excluding Central Luzon (where tungro infestation damaged the crop).

Comparison of IRRI Trials with Farmers' Practices

IRRI trials are fundamentally different from farmers' practices with the trials carefully controlled, and typically only one thing allowed to vary with all others held optimum.

Nevertheless, the trials are undertaken to be helpful to farmers and comparison is required to obtain inferences for farm recommendations. Comparisons have been made, and the recommended farm practices are adapted from the trials, with some adjustments and allowances by informed people on an ad hoc basis using whatever other information is available.

The comparisons made here require some interpretation and some reservation. Thus we say that the slope of the yield response to fertilizer is about the same in the wet season for IRRI trials and for the average of all farmers growing HYV on irrigated land, although the level of yields for each fertilizer application is about twice as high for IRRI as for the farmers. In the trials, the phosphorus, and potassium are held constant at optimum levels, the weeds and grasses, pests and diseases are carefully

6/ UNDP-FAO Soil Fertility and Research, Philippines, Final Report, Vol. I, p. 134-A.

controlled, etc., and only the nitrogen application is varied. For the farms, we have little information on the other factors and the weak "control" that is possible with multiple regression analysis is not like the controls for the trials.

Despite these reservations, the very similar average fertilizer response during the wet season for IRRI trials and for farmers on irrigated land was surprising new information that changes the perspective on the problem of low rice fertilization and low yields. One must bear in mind that these are average relationships and that year-to-year variations are large, as shown later (Fig. 12).

Wet Season

As mentioned earlier, the price per kg. of N fertilizer in the Philippines has averaged about 4 times the price received by farmers for a kg. of palay, and a ratio of 2-1/2 pesos of palay per peso of fertilizer is a rule of thumb often used to calculate the most profitable return from fertilization. If 4 to 1 is used for the fertilizer-palay price ratio, and a return of 2-1/2 to 1, excluding harvester's share, is calculated as the most profitable point, then this is reached where the yield response to fertilizer is 10 kgs. of palay per kg. of plant nutrient (N, or N+P). This marginal response is shown for the several curves in the lower panel of figure 11. For the IAS-wet season, 1969-70, the most profitable fertilizer usage increases from the 35 kgs,, calculated above for the higher cost that farmers reported paying for fertilizer, to nearly 50 kgs., as the marginal response curve is relatively flat, and the most profitable rate of fertilization is rather sensitive to price-cost changes.

The other wet season curves, the IRRI summary and the IAS, 1971-72 Philippines excluding C. Luzon, the most profitable fertilizer usage is about the same, a little under 50 kgs. These marginal response curves are much steeper, however, so that the most profitable rate of usage is less sensitive to price changes. This means that even with considerable shifts in the fertilizer palay price ratio, or in the rule of thumb about rate of return, there would be little change in the most profitable rate of fertilization. Although the individual farmer will have to adjust to his own fertilizer-response relationship, for the average shown here, the most profitable application is a little less than 50 kgs. N/ha., and there is a considerable penalty for applications much above or much below this rate. For example at 60 kg. N/ha., the marginal return is only 4 kgs. of palay for each kg. of N, and at 68 the marginal is zero.

For a fertilizer authority that wished to obtain the maximum amount of palay from a given quantity of fertilizer available, rather different calculations are appropriate. If the allocation is made to maximize farmers' incomes, the amount to be supplied would be for fertilization at a little under 50 kg. N/ha., as explained above. The authority would obtain about 20 kg. of palay for each kg. of N allocated. For smaller quantities of N/ha., however, there is a divergence between the farmers' and the authorities interests. For example at 25 kg. N/ha. fertilization, the farmer is using less fertilizer than his optimum rate of nearly 50 kgs., but the authority would be obtaining 26 kg. of palay per kg. of N allocated, as compared with only 20 to 1 for the allocation of 50 kg. N/ha.

Thus, for the IRRI wet season summary and for the IAS wet season 1969-70 curve for the Philippines other than C. Luzon, there is a distinct divergence between what the individual grower would prefer (around 50 kg. N/ha.) and what would maximize the extra rice that can be produced by a given (limited) supply of fertilizer. The amount of extra palay that can be produced by the quantity of fertilizer available can be increased by reducing the allocation per hectare below the recommended or most profitable rate for the individual farmer. By a coincidence (I think) the marginal rate for the UNDP curve about coincides with the rate per hectare that is appropriate for the authority to use to estimate the palay production that can be obtained from a given limited quantity of fertilizer.

Qualifications

An important qualification is that the IRRI curves are an average of wet season data from different years, and the two IAS curves are each for only one season. As shown in the 1972 annual report of the Agricultural Economics Department of IRRI (reproduced here as figure 12) the year-to-year variation in fertilizer response is surprisingly large in the wet season for the carefully controlled IRRI trials. Thus, even for IR-8 in the wet season, out of the 7 years' trials, two (1966 and 1970) showed poor fertilizer response, whereas other years showed much more response. For IR-20, there are 2 good years (1970 and 1972) and 2 years with little yield response to fertilization. Although the IAS data for Philippine farmers for the two years shown have similar response to fertilization, large year-to-year variation seems likely.

The set of curves of trials and the farm surveys for the wet season irrigated HYV point to similar average most profitable fertilization rates--a little under 50 kg. N/ha.--with nitrogen-palay price ratios about 4 to 1. This is somewhat below recommended rates based upon earlier and less complete data. Nevertheless, the shapes of the curves are different, and the coefficients determining the shape have uncomfortably large error terms and annual variations. The level of the yield curves varies greatly from the farm practices to IRRI controlled trials.

Dry Season - IAS and IRRI

With all these limitations for the wet season data, they are more nearly convergent than the dry season information. The IAS cross-section and regression results for 1969-70 wet season were discussed above. No comparable data were collected for the 1971-72 dry season, and no other data have been tabulated. The general picture was shown in figures 11 and 12 above. Whereas the IAS curves were similar in both level and shape in the wet and the dry season, the IRRI experiments are in sharp contrast between the seasons in slope, level, and variation from year to year. The dry season fertilizer-response of trials in IRRI experiments are generally superior to the UNDP standard, both in level of yield and response to fertilizer (slope). The IRRI experiments obtained considerably higher response through low and intermediate ranges of fertilization and they are equal to the UNDP at the 10 to 1 marginal rate at around 90 kgs. N/ha., the most profitable rate of application where the N/palay price ratio is 4 to 1.

The smaller variation in fertilizer response during the dry season than in the wet season in IRRI experiments is shown in figure 12. For IR-8, the almost uniform strong advance occurs in 5 of the 6 years, and the 6th year response is above the average in the wet season. All 4 IR-20 responses are strong.

For the IAS survey of farmers, the principal curve fitted for the dry season is not sufficiently different from the wet season curve to require any comment. However, the sample for the dry season is rather small, and the fertilizer-response curve is not firmly established by the regression calculation. An alternative regression curve is shown which has considerably greater slope than the one for the wet season, and a higher rate of fertilization would be profitable. The great difference from the IRRI experiments and trials has been bridged by the water-stress unsupervised farm trials.

In a series of trials, with severe, moderate, and light water-stress options, the moderate water stress was judged to be the most representative of average irrigated-paddy conditions in the dry season. The fertilizer response, and the differences in average yields between HYV and TRAD varieties were similar to the results of the IAS dry season data 7/.

7/ Thomas H. Wickham, in Annual Reports, IRRI and mimeo seminar papers, including "Major Constraints to Rice Production with Emphasis on Yields in the Philippines" jointly with Robert W. Herdt, Apr. 22, 1974; and, "Effect of Moisture Stress Periods in Relation to Irrigation Systems" April 23-27, 1973.

Comparison with IRRI's Trials in Farmers' Fields

Each year IRRI conducts experiments in farmers' fields to study varietal response to nitrogen fertilization under management conditions that are within reach of most Asian farmers (p. 162, 1971 Annual Report). The trials are on irrigated land in Laguna, and the varieties reported include IR-8, IR-5, and non-IRRI HYV in the earlier years, and the IR-20 series in recent years in both the wet and the dry seasons. Before the comprehensive analysis of IRRI fertilizer response trials became available, the trials in farmers fields were compared with the IAS data with results so similar to those that have been discussed above that the discussion has been eliminated. Since the data are not available in quite the form in which they are summarized here, they are shown in tables 5 and 6 and in figures 13 and 14 with comparisons.

Low-Yield and High-Yield Farms

An attempt was made to compare the characteristics of farms with high yield with those getting low yields as compared with the average for all lowland irrigated farms based on IAS data, 1969-70. Farms were arrayed by yield separately for HYV and traditional varieties, and the averages were computed for the highest fifth, the lowest fifth, and the average, as shown in tables 7 and 8. For HYV farms, the upper quintile averaged 4270 kgs. per hectare yield as compared with 1010 kgs. for the lower quintile, or a ratio 4270/1010 = 4.2 to 1 and a much higher proportion (83 percent vs. 42 percent) used fertilizer as well as chemicals (80 percent vs. 40 percent), their expenditures per hectare were several times as high and they reported

more adequate irrigation. The average was intermediate in each of these respects. For the traditional variety group, the same general pattern prevailed with yields in the upper quintile 880 kgs. lower than the HYVs and the average 440 kgs. lower. Somewhat fewer traditional variety growers used fertilizer than the corresponding HYV group, and they spent somewhat less per hectare and purchased a negligible quantity of chemicals.

Implications for Research and Policy

If these comparisons indicate the present situation for IRRI and farm technology, what can be done to exploit the yield potentials of HYV on Philippine farms? International comparisons show that fertilizer expansion in the Philippines has been slower than in some other Asian countries 8/ 9/. The research need is to know what has to be done to raise the level of yield at any fertilizer level. As of now, one can only cite the usual several things that are essential for good yields, and the skills required for trained extension workers (pp. 323-24 Rice Manual, 1970.)

As IRRI has stressed, and is now investigating, we do not know what accounts for the variation in rice yields under field conditions. We do know from the 1970 data analysis and other studies that farmers are using very limited quantities of chemicals for control of weeds and diseases and

8/ "The Impact of Devaluation on Fertilizer Use and Profitability in Philippine Rice Production," p. 1 and fig. 1, mimeo, IRRI, May 21, 1970. Similar results are reported by John T. Shields and Robert C. Gray of TVA in "The Fertilizer Industry in the Philippines," with the Technical Working Committee, Presidential Fertilizer Commission, in cooperation with AID, 1971.

9/ "The Green Revolution: Second-Generation Problems," p. 699; pp. 698-710; AJAE, Dec. 1970, Vol. 52, No. 5.

pests. For weed and grass control, there are specific recommendations that would seem to be clearly profitable for the small proportion of farmers who have good water control and water supply.

Weeds and grass can be controlled without herbicides as reported from Taiwan, S. Korea, and Japan. But the average size of paddy fields is about twice as large in the Philippines as in these countries, irrigation is less adequate, and the weeds and grass may grow faster under the wet, tropical climate of the Philippines. It may be that hand control of weeds and grasses is so arduous in paddies in the Philippines that it is not a practical recommendation. (This is the judgment of one of the Taiwan technicians who worked on the ASPAC multiple-cropping project in Nueva Ecija.) We have little specific information on the weed control effort, or the damage due to inadequate control. Barker and associates in a Gapan study weighed weeds and found more direct relationship to fertilizer application than the fertilizer-yield relationship.

Wet Season, Irrigated, HYV

For irrigated HYV, the wet season and the dry season have very different fertilizer response, and this report has more nearly convergent results for farms and experiments for the wet season than for the dry. In the wet season, the widely used UNDP yield curve for varying rates of fertilization is higher than the IRRI and far above the farm (IAS) yield throughout the full range of fertilization rates.

The implication is that the route to higher profitable yields lies in other improved practices that will make possible a better and more dependable fertilizer-yield response. IRRI is engaged in a research project to ascertain the constraints that are holding palay yields well below those obtained in trials, demonstrations, and on many farms--perhaps one-fifth of all farms.

Dry Season, Irrigated, HYV

In the dry season, the UNDP curve and the IRRI yield curve are very similar, with IRRI obtaining somewhat higher average yields and marginal response through lower and intermediate ranges of fertilization. The 10 to 1 response rate is reached at the same point for each of them, at around 90 kg. N/ha. Whereas, the farm survey (IAS) yield levels and marginal response are considerably lower.

Since most of the rice in the Philippines, irrigated and rainfed, is grown in the wet season, and a minor proportion has sufficient water for irrigation in the dry season, it would be desirable to develop varieties that would have high response sustained to high rates of fertilizer application for the wet season, and then teach farmers the technology to exploit the high yield response of the new varieties. Since solar radiation is so important for the HYVs developed, the option of developing HYVs for the wet season may be difficult, or even not feasible. But, it would be helpful in the Philippines--and elsewhere in the monsoon rice regions.

The other possibility is to develop better irrigation that would provide water for the dry season and then teach the farmers to exploit the yield response of the HYVs.

Since both of these options appear to be long-range rather than immediate possibilities, one of the things that appears feasible for the present is to find out why farmers are getting so little of the high production response and yield capabilities of HYV in the dry season, and remove these obstacles. This is a research task that requires neither scientific breakthroughs nor large financial or practical administrative allotments to begin the many steps required. IRRI (economic section) conducted a preliminary study of yield variation causes on a sample of farms, and has launched a multi-disciplinary project to study "the factors preventing Asian rice farmers from getting the high yields that have been demonstrated to be possible using semi-dwarf rice varieties and complementary management practices, and a number of other projects underway or proposed are relevant, including ASPAC multiple cropping and the Israeli Moshav Cooperative project.

10/ R.W. Herdt, S.K. DeDatta, K.A. Gomez and T.H. Wickham, "Identifying Constraints to Higher Yields on Asian Rice Farms." Working Paper I, International Rice Agro-Economic Network, June 1974.

Table 1.--Yield Distribution Averages and Medians in Kilograms

	Mean (1)	Median (2)	Difference (1) - (2)	Number of farms	Percent
	- - - - - - - -	Kilograms	- - - - - - - -		
1st Semester Irrigated					
HYV	2385	2262	123	351	55
Traditional ..	1989	1830	159	265	42
Difference ...	396	432	---	---	--
Total	---	---	---	1/634	100
2nd Semester Irrigated					
HYV	2262	2147	115	319	67
Traditional ..	1905	1663	242	144	30
Difference ...	357	484	---	---	--
Total	---	---	---	1/479	100
1st Semester Rainfed					
HYV	1778	1606	172	259	33
Traditional ..	1588	1465	123	485	62
Difference ...	190	141	---	---	--
Total	---	---	---	1/778	100
2nd Semester Rainfed					
HYV	1426	1170	256	146	49
Traditional ..	1390	1188	202	150	50
Difference ...	36	-18	---	---	--
Total	---	---	---	1/298	100
Upland					
1st Semester	1140	968	172	338	
2nd Semester	1580	1144	436	29	
Total	1307			367	

1/ Includes a small number of mixed HYV and TRAD.

Source: Subsample of Bureau of Agricultural Economics Integrated Agricultural Survey, crop year 1969-70.

Table 2.--Regression results for irrigated rice production, first semester 1969-70, Philippines*

Eq. No.	Dependent Variable	R^2	Constant	X_f Fertilizer per hectare	X_c Chemicals peso/ha.	X_f^2	Specification
				HYV			
1.1	HYV Yield (kilos) p. 37 3rd run 11/24	.17	1953	18.11 (5.791)	23.50 (5.889)	-0.0858 (0.0565)	Fertilizer in kilos of (N+P) All reporting n = 320
1.3	HYV Yield (kilos) p. 27 3rd run 11/24	.18	1855	12.00 (3.385)	20.75 (5.956)	-0.0316 (0.0199)	Fertilizer in pesos All reporting n = 320

	Dependent Variable	R^2	Constant	X_f Fertilizer per hectare	X_c Chemicals peso/ha.	$X_f X_c$	X_c^2	
				NON-HYV				
2.2	Non-HYV Yield (kg.) p. 118 3rd run 11/29	.23	1866	6.442 (4.079)	45.54 (22.54)	.4534 (.3996)	-2.100 (.7208)	Fertilizer in Kgs. of (N+P) Users only n = 138
2.4	Non-HYV Yield (kg.) p. 109 3rd run 11/29	.35	1922	7.497 (2.127)	51.53 (20.97)		-1.588 (.5806)	Fertilizer in pesos Users only n = 138

	Yield		Fertilizer per hectare N + P	N	P	Chemicals	All reporting	
	Kg/Ha.		Peso/Ha.	Kg/Ha.		Peso/Ha.		
				HYV				
1.1	Means	2420	38.16	21.57	16.29	5.287	6.152	n = 320
	(S.D.)	(1108)	(43.82)	(26.91)	(21.38)	(12.89)	(10.28)	Price of N+P = 1.76 pesos
1.3	Means	2627	56.53	(31.96)	24.13	7.833	7.737	Users only
	(S.D.)	1056	(42.49)	(27.21)	(22.09)	(15.05)	(11.59)	n = 216
				NON-HYV				
2.2	Means	2005	28.68	18.57	12.25	6.315	3.380	n = 238
	(S.D.)	(943.7)	(35.10)	(25.00)	19.23	(12.40)	(6.863)	p. 40 3rd run 11/29 Price of N+P = 1.54 pesos
2.4	Means	2116	49.46	32.02	21.13	10.89	4.897	Users only n = 138
	(S.D.)	(912.0)	(33.10)	(25.44)	(21.23)	(14.69)	(8.076)	p. 88 3rd run 11/29

Cont'd.

Table 2a.--Regression results for irrigated rice production, first semester 1969-70, Philippines (Cont'd)

Eq. No.	Dependent Variable	Region								
		R1 Ilocos	R2 Cagayan	R3 Central Luzon	R4 Southern Tagalog	R5 Bicol	R6 Eastern Visayas	R7 Western Visayas	R8 N & E Mindanao	R9 S & W Mindanao
					HYV					
1.1	HYV Yield (Kg.)	---	295.5 (203.7)	---	---	186.3 (164.1)	---	---	---	197.6 (185.4)
1.3	HYV Yield (Kg.)	---	308.2 (201.0)	---	---	204.6 (166.7)	---	---	---	209.4 (179.7)
					NON-HYV					
2.2	Non-HYV ield (Kg.)	-978.7 (251.8)	---	---	---	---	-826.5 (362.7)	-314.0 (293.9)	---	---
2.4	Non-HYV Yield (Kg.)	-786.0 (245.4)	---	---	250.6 (192.0)	---	-623.4 (355.2)	---	559.8 (431.2)	---
					HYV					
1.1	Means (S.D.)	.0469	.0969	.2186	.1438	.1719	.0656	.0469	.0625	.1469
1.3	Means (S.D.)	.0648	.1065	.2825	.1759	.1111	.0324	.0602	.0694	.0972
					NON-HYV					
2.2	Means (S.D.)	.1765	.1008	.3867	.1218	.0588	.0504	.0588	.0336	.0126
2.4	Means (S.D.)	.1377	.0725	.4493	.1667	.0217	.0507	.0652	.0362	.0000

Cont'd.

Table 2b.--Regression results for irrigated rice production, first semester 1969-70, Philippines (Cont'd)

Eq. No.	Dependent Variable	Size					Tenure			
		S1 Lower 1/5	S2 2nd 1/5	S3 3rd 1/5	S4 4th 1/5	S5 Upper 1/5	T1 Owner	T2 Part Owner	T3 Lease	T4 Tenant
					HYV					
1.1	HYV Yield (Kg.)	---	---	---	---	---	123.2 (135.7)	---	---	
1.3	HYV Yield (Kg.)	---	---	---	---	---	---	---	---	
					NON-HYV					
2.2	Non-HYV Yield (Kg.)	---	---	---	-391.0 (181.1)	-407.2 (212.6)	404.7 (212.2)	198.2 (202.6)	---	
2.4	Non-HYV Yield (Kg.)	---	---	---	-301.9 (178.7)	-270.6 (207.7)	421.1 (209.0)	213.6 (198.9)	---	
					HYV					
1.1	Means (S.D.)	.1875	.1281	.1813	.2063	.2844	.2906	.2469	.0969	.3656
1.3	Means (S.D.)	.1991	.1343	.1852	.2269	.2361	.2361	.2500	.1250	.3889
					NON-HYV					
2.2	Means (S.D.)	.2311	.1639	.1513	.2521	.1891	.2647	.1849	.1176	.4328
2.4	Means (S.D.)	.1884	.1812	.1232	.2899	.2029	.2174	.1884	.1159	.4783

Cont'd.

Table 2c.--Regression results for irrigated rice production, first semester 1969-70, Philippines (Cont'd)

Eq. No.	Dependent Variable	Irrigation				
		I1 Irrigation Fee	I2 Pump	I3 Inadequate	I4 Communal	I5 Private
				HYV		
1.1	HYV Yield (Kg.)	1.33 (1.07)	---	-192.6 (130.8)	---	---
1.3	HYV Yield (Kg.)	1.33 (1.06)	---	-176.8 (129.7)	---	---
				NON-HYV		
2.2	Non-HYV Yield (Kg.)	.10	472.0 (284.4)	-334.1 (157.3)	-362.4 (177.8)	-282.0 (257.0)
2.4	Non-HYV Yield (Kg.)		501.5 (280.4)	-352.1 (155.2)	-347.4 (176.3)	-263.0 (252.4)
				HYV		
1.1	Means (S.D.)	24.78 (54.66)	.1219	.2781	.2781	.2250
1.3	Means (S.D.)	30.15 (62.76)	.1111	.2593	.2731	.2083
				NON-HYV		
2.2	Means (S.D.)	20.09 (44.71)	.1134	.4118	.3571	.1807
2.4	Means (S.D.)	24.02 (48.89)	.1449	.3841	.2971	.1957

* Variables having a t-ratio of less than 1.0 were omitted from this table but were included in the statistical analysis if at any step the t-ratio reached 1.0. Numbers in parenthesis below the regression coefficients are the respective standard errors and those below the means are the standard deviations.

Interpretation of Dummy Variables

The coefficients shown in the upper part of the table on page 15a represent the yield differences in kilograms of palay of the region from the region selected as the standard (Central Luzon) and the figure in parenthesis below each coefficient is the standard error.

The means shown in the lower part of the table represent the relative frequency of the region in the sample, with the sum of the means for all the regions adding up to 1.000.

The same interpretation holds for the other dummy variable groups shown on the 2 following pages. For the size of farm group, size 3 is the standard from which yield differences are calculated for other size groups. For tenure, tenant (not shown) is the standard; for type of irrigation ownership, government ownership is the standard; for adequacy of system, adequate is the standard; and for source of water, stream diversion is the standard.

Table 3 .--Yield-Fertilizer Cross Classification, Irrigated, HYV and TRADitional Varieties, in each semester, 1969-70

Pesos per hectare	Irrigated									
	1st Semester					2nd Semester				
	HYV		TRAD		HYV less TRAD	HYV		TRAD		HYV less TRAD
	Yield	No. in sample	Yield	No. in sample		Yield	No. in sample	Yield	No. in sample	
	Kgs.		Kgs.		- - - - Kgs. - - -			Kgs.		Kgs.
0 ...	2055	130	1984	121	+ 71	2165	138	1901	89	+264
-15 ...	2587	27	1998	14	+589	1866	19	1958	5	- 92
16-25 ...	2336	29	1905	23	+431	1962	23	1584	11	+378
26-35 ...	2710	30	1813	15	+897	2306	17	2477	9	-171
36-45 ...	2446	18	1989	25	+457	2160	14	1967	4	+193
46-55 ...	2614	18	2191	19	+423	2596	21	1786	6	+810
56-65 ...	2737	25	2407	7	+330	2046	13	2116	4	- 70
66-75 ...	2411	17	2231	10	+180	2636	15	2116	5	+520
76-85 ...	2407	11	2398	9	+ 9	2592	15		1	
86-95 ...	2939	11	1980	7	+959	3089	9		2	
96-105 ...	2724	8		1		1663	- 4	2587	4	-924
106-115 ...	3291	4	3181	3		2825	5		0	
116+	3551	23	2917	10	+634	3049	25	2451	4	+598
	p. 107		p. 106-7			8-23-73, p. 79				

Table 4.--Philippines, Fertilizer-Yield Tabulation, Rice 1969-70
HYV and Traditional Varieties
Rainfed Lowland, 1st Semester

Value of fertilizer pesos/hectare	No. in sample		Yield		Difference
	HYV	TRAD	HYV	TRAD	HYV-TRAD
			- - - Kgs. - - -		
0	141	221	1602	1478	124
-15	8	37	2050	1483	567
16-25	13	65	1980	1654	326
26-35	18	39	1883	1562	321
36-45	8	27	2354	1439	475
46-55	16	25	1791	1879	-88
56-65	19	20	2160	2055	105
66-75	9	8	2046	1830	216
76-85	5	9	2226	2068	158
86-95	6	6	2332	1654	678
96-105	6	12	2561	2578	-17
106-115	1	1	1993	2754	
116+	9	15	2279	2121	158
Total	259	485			
Users	118	264			
% of users	46%	54%			
Med. of users ..	5.0	3.			
Mean of users ..					

Table 5 .--Effect of Nitrogen on HYV rice yield in farmers' fields in Laguna (IRRI conducted experiments)

Year	Dry season						Wet season							
	1967	1968	1969 1/	1970 2/	1971	5-year average		1967		1968	1969 1/	1970 2/	1971	4-year average
Number of varieties	(5)	(5)	(5)	(5)	(7)			(5)		(6)	(5)	(4)	(7)	
N Kg./ha.	- - Rough rice, kilograms per hectare - -						N/kg. ha.		N/kg. ha.	Rough rice, kilograms per hectare				
0	3,799	5,152	4,430	5,420	6,120	4,984	0 ...	2,929	0 ..	3,479	5,420	4,675	4,100	4,418
50	5,051	6,629	6,570	6,760	7,920	6,586	20 ..	3,903	25 .	4,619	5,770	5,075	4,650	5,028
100	6,468	8,786	7,750	8,100	8,680	7,957	40 ..	3,936	50 .	5,260	5,850	5,788	4,700	5,400
150	7,218	8,863	8,270	7,600	8,700	8,130	60 ..	3,982	75 .	5,413	5,460	5,950	3,800	5,156
							80 ..	4,060						
	IR-8													
0	4,409	5,928	3,850	5,700	7,400	5,457	0 ...	2,756	0 ..	3,416	6,200	4,200	4,200	4,504
50	5,509	6,418	7,200	8,100	8,600	7,165	20 ..	3,720	25 .	5,332	6,300	4,500	4,500	5,158
100	7,547	10,196	8,600	9,400	9,600	9,069	40 ..	4,187	50 .	5,843	7,100	5,450	4,800	5,798
150	8,892	10,474	9,357	9,500	10,000	9,645	60 ..	5,070	75 .	6,082	7,382	6,200	2,200	5,466
							80 ..	5,539						

1/ 1969 figures read from chart in 1969 Annual Report.

2/ 1970 figures read from chart in 1970 Annual Report.

Source: IRRI Annual Reports.

Table 6.--Fertilizer-Rice Yield Curves Shown in Figure 14

Formula: Yield, palay kgs./ha. = Constant + X_F (kg. N/ha.) + $(X_F)^2$

Formula	Season	Constant	X_F(Fertilizer)	X_F^2	
			Kgs./Ha.		
Trials in Farmers Fields					
All HYV - 5 yr. avg. ..	Dry	4935.6	43.053	-.1429	
All HYV - 4 yr. avg. ..	Wet	4399.1	35.964	-.3416	
IR-8 - 5 yr. avg. ..	Dry	5380.8	45.916	-.1132	
IR-8 - 4 yr. avg. ..	Wet	4456.1	43.684	-.3944	
UNDP-HYV	Av. Both	4638	32.355	-.125	
IRRI-Avg. HYV (1966-71)	Dry	4567	41.85	-.1771	
IRRI-Avg. HYV (1966-71)	Wet	4091	31.53	-.2321	
IAS-Irrigated					
HYV - '69-'70	Dry	2041.4	11.188	-.0419	alternat
HYV - '69-'70	Dry	1806.3	20.78	-.0497	curves
HYV - '69-'70	Wet	2095	18.112	-.0858	
Non-HYV - '69-'70	Wet	1922.5	11.5	None	
HYV - '71-'72	Wet	1691	31.58	-.2329	

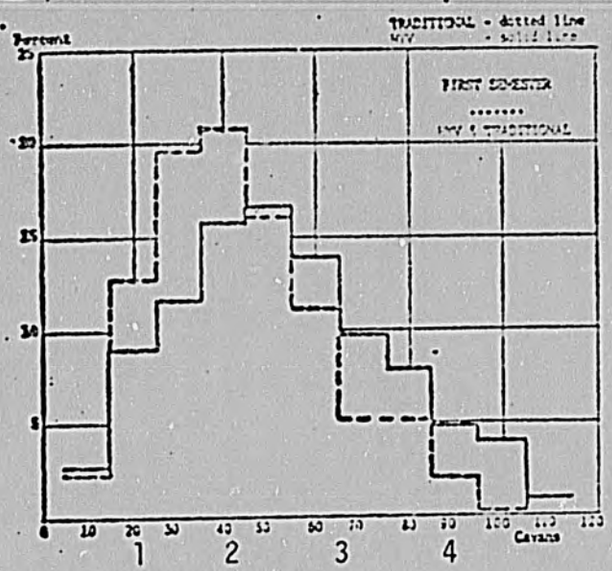
Table 7.--Comparison of average-yield with high- and low-yield farms, irrigated, wet season, crop year 1969-70

	HYV		
	Lower quintile 20%	Upper quintile 20%	All
Region	Same for all		
Tenure	Greater number of owners and part owners		
Harvest Month		November	
Farms Using:			
Fertilizer	42%	83%	68%
Chemicals	40%	80%	66%
Adequate Irrigation	57%	90%	72%
System Ownership			
Government	21%	36%	39%
Communal	25%	27%	28%
Private	26%	27%	22%
No report	28%	10%	11%
Means			
Fertilizer (value (pesos/Ha.)	11.5	63.9	40.0
Chemical Value (Pesos/Ha.)	2.1	12.2	6.3
Production (Kgs.)	2136	8360	4721
Harvested area (Ha.)	2.09	1.96	1.88
Size Farm (Ha.)	3.89	5.21	3.52
Yield (Kgs./Ha.)	1021	4264	2438

Table 8.--Comparison of average-yield with high- and low-yield farms, irrigated, wet season, crop year 1969-70

	Traditional		
	Lower quintile 20%	Upper quintile 20%	All
Region	Ilocos has more		
Tenure	Same as HYV		
Harvest Month	November	December	December
Farms Using:			
Fertilizer	38%	64%	59%
Chemicals	26%	65%	43%
Adequate Irrigation	41%	78%	59%
System Ownership			
Government	14%	43%	35%
Communal	45%	29%	36%
Private	17%	16%	18%
Don't know	24%	13%	11%
Means			
Fertilizer value (Pesos/Ha.)	12.2	38.6	33
Chemical value (Pesos/Ha.)	1.5	3.7	3.3
Production (Kgs.)	1672	5883	3881
Harvested Area (Ha.)	2.05	1.80	1.98
Size Farm (Ha.)	3.21	2.45	2.61
Yield (Kgs./Ha.)	814	3388	2006

FIGURE 1: YIELD DISTRIBUTION, IRRIGATED PADDY, 1970



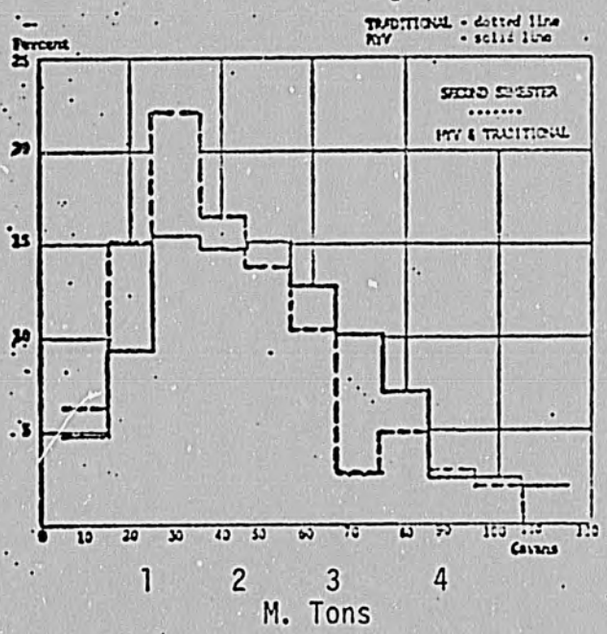
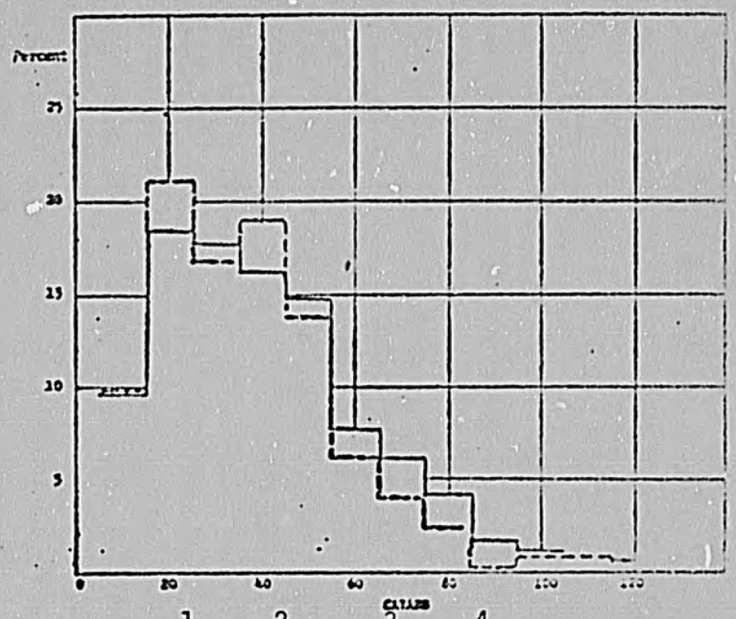
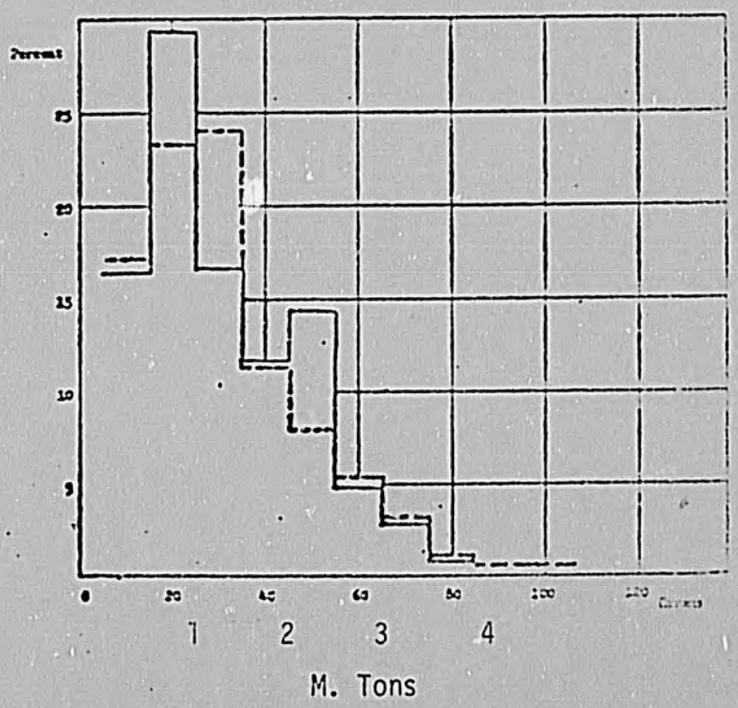


FIGURE 2: YIELD DISTRIBUTION, RAINFED PADDY, 1970
HYV (solid line), TRADITIONAL (dotted line)

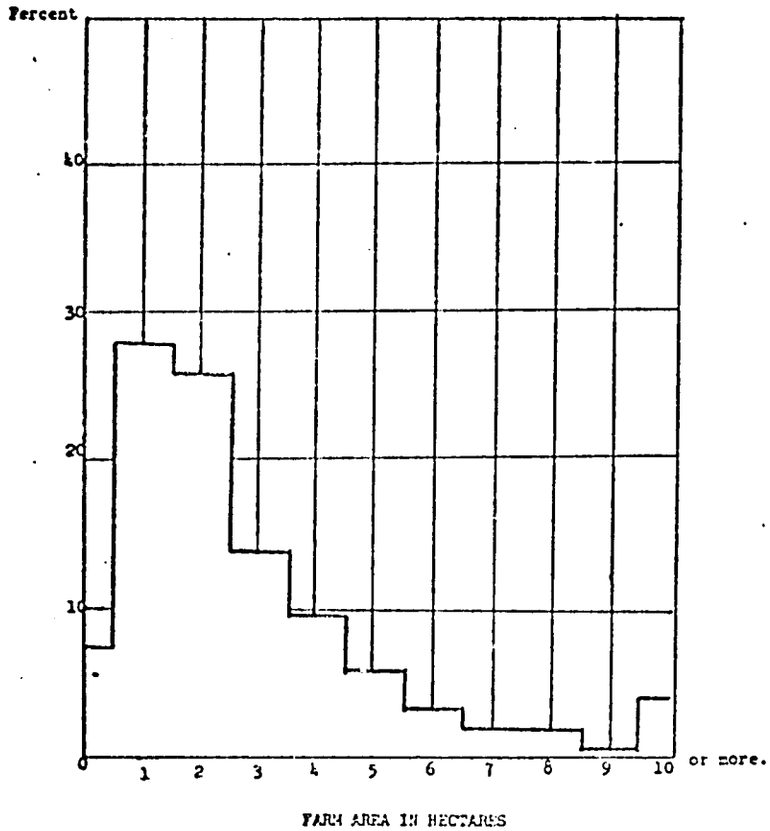
First Semester



Second Semester



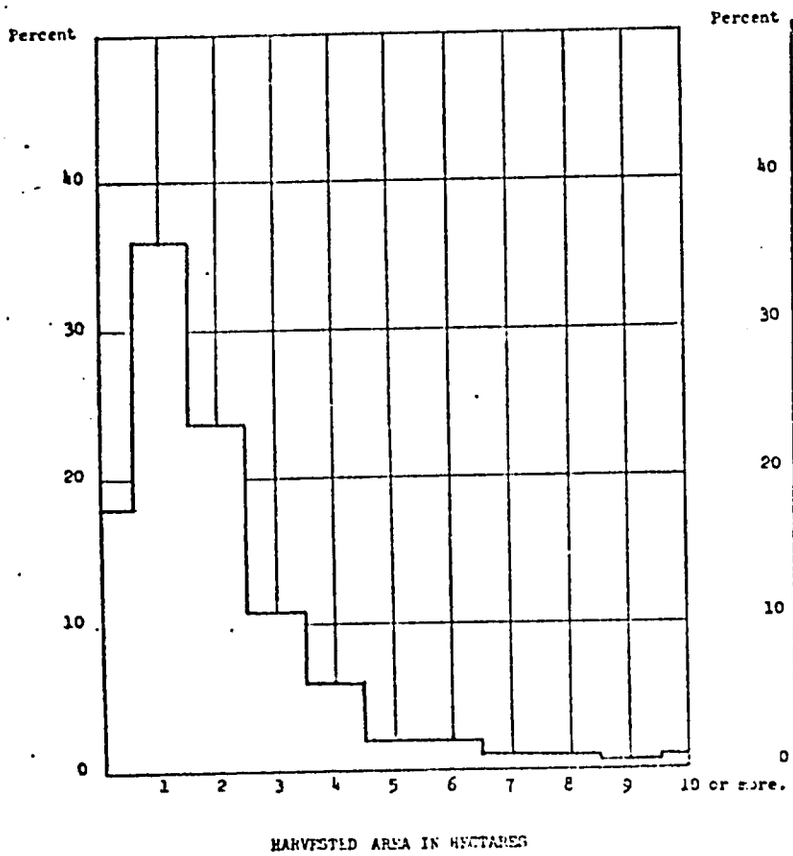
size of farm, 1970



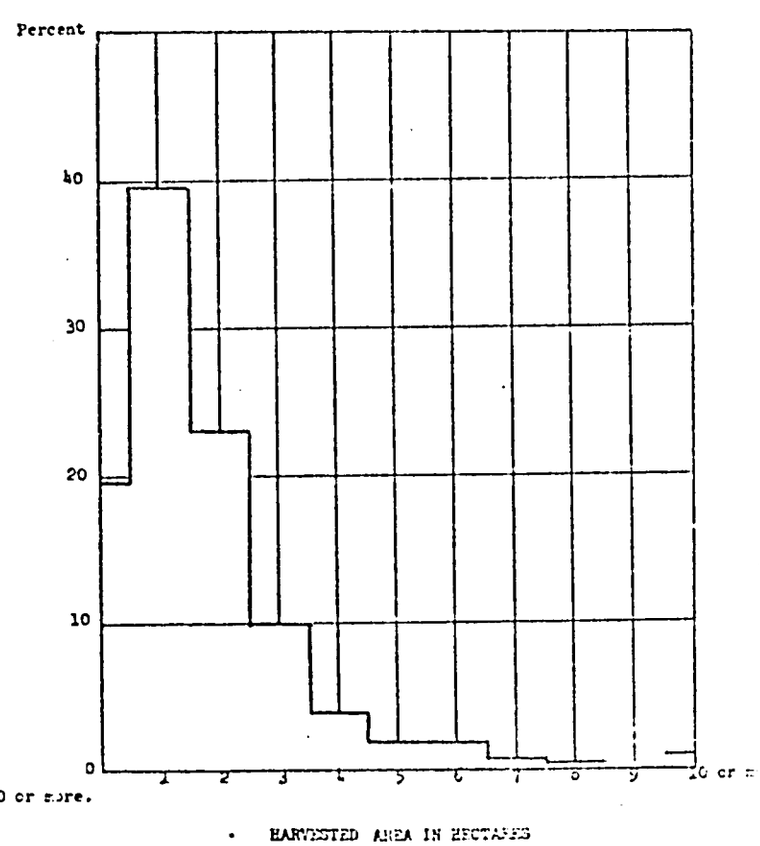
SOURCE: IAS - Sample, BAECON

Figure 4: Irrigated Paddy - Distribution of farms by area harvested, 1st Semester, 1970

Figure 5: Nonirrigated Paddy - Distribution of farms by area harvested, 1st Semester, 1970

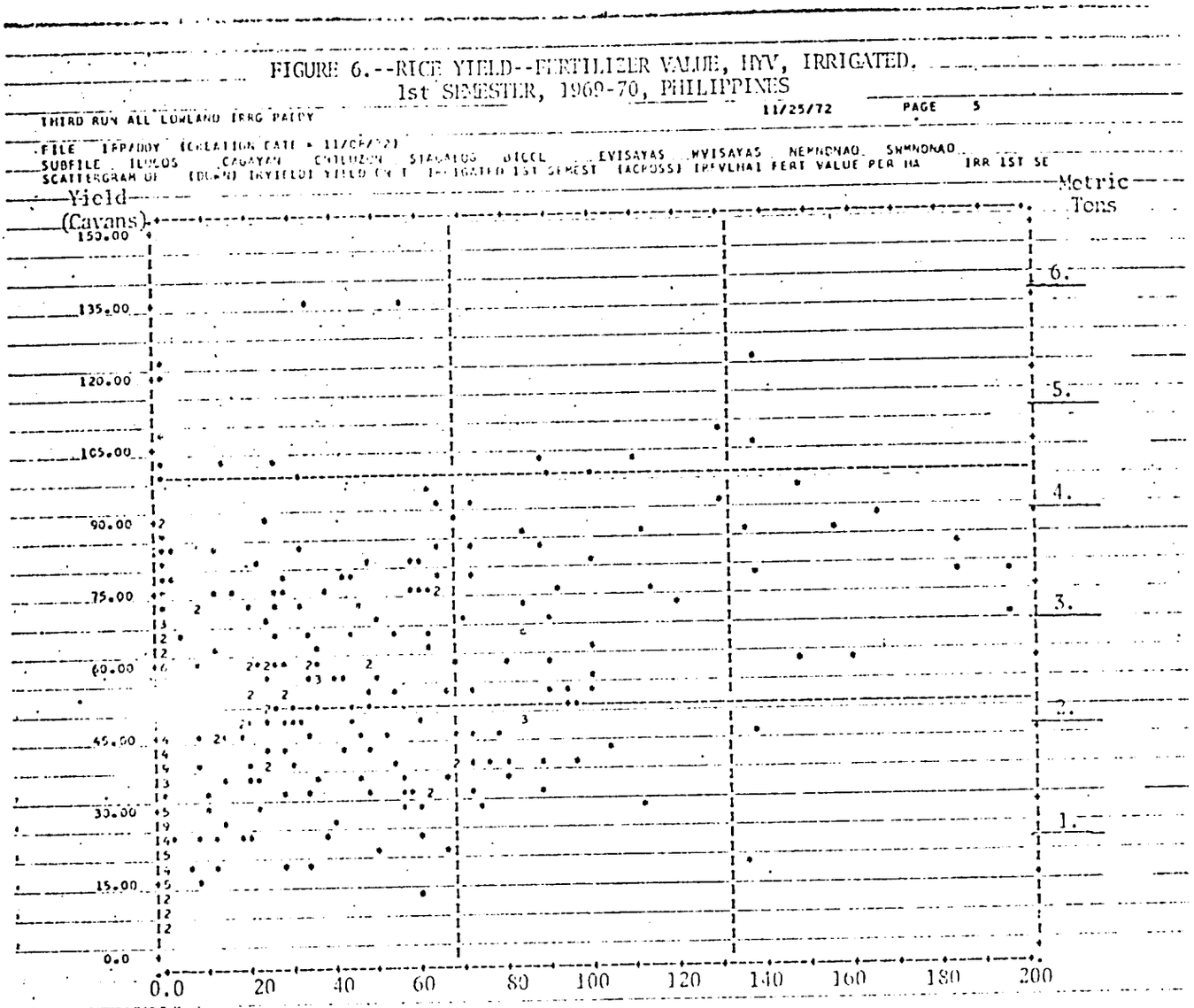


SOURCE: IAS - Sample, BAECON



SOURCE: IAS - Sample, BAECON

FIGURE 6.--RICE YIELD--FERTILIZER VALUE, HYV, IRRIGATED, 1st SEMESTER, 1969-70, PHILIPPINES



THIRD RUN ALL LOWLAND IRRG PADDY 11/25/72 PAGE 6

STATISTICS..

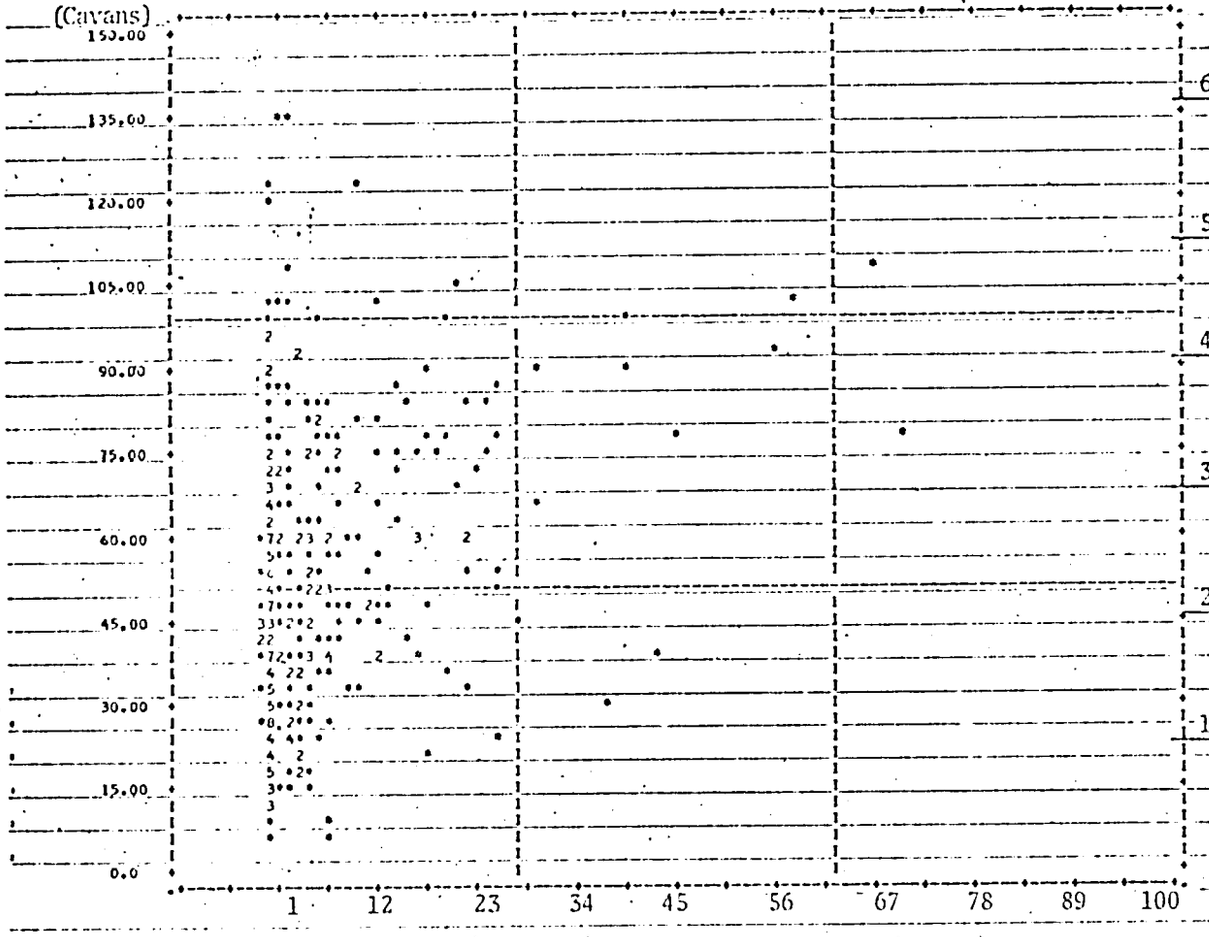
CORRELATION (R)-	0.35787	R SQUARED -	0.12451	SIGNIFICANCE -	0.00001
STD ERR OF EST -	22.99591	INTERCEPT (A) -	46.90979	SLOPE (B) -	2.05477
PLOTTED VALUES -	318	EXCLUDED VALUES-	2	MISSING VALUES -	0

********* IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

FIGURE 7.--RICE YIELD--CHEMICALS VALUE, HYV, IRRIGATED, 1st SEMESTER, 1969-70, PHILIPPINES

THIRD RUN ALL LOWLAND IRRG PADDY 11/25/72 PAGE 7

FILE IRPADDY (CREATION DATE = 11/06/72)
SUBFILE ILOCOS CAGAYAN CNTLUZON STAGALOO BICOL EVISAYAS WVISAYAS NEMNDNAO SWMNDNAO
SCATTERGRAM OF (DOWN) IRYIELDI YIELD ON T IRRIGATED 1ST SEMEST (ACROSS) IRCVLHAI CHEM VALUE PER HA IRR 1ST SE



Chemicals, value per hectare in pesos

THIRD RUN ALL LOWLAND IRRG PADDY 11/25/72 PAGE 8

STATISTICS..

CORRELATION (R)- 0.30039 R SQUARED - 0.09023 SIGNIFICANCE - 0.00001

STD ERR OF EST - 23.40672 INTERCEPT (A) - 50.26853 SLOPE (B) - 7.14931

PLOTTED VALUES - 319 EXCLUDED VALUES- 1 MISSING VALUES - 0

********* IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

FIGURE 8.--PALAY YIELD - FERTILIZER RELATIONSHIP, IRRIGATED, IRRI AND TRAD Wet Season, 1969-1970

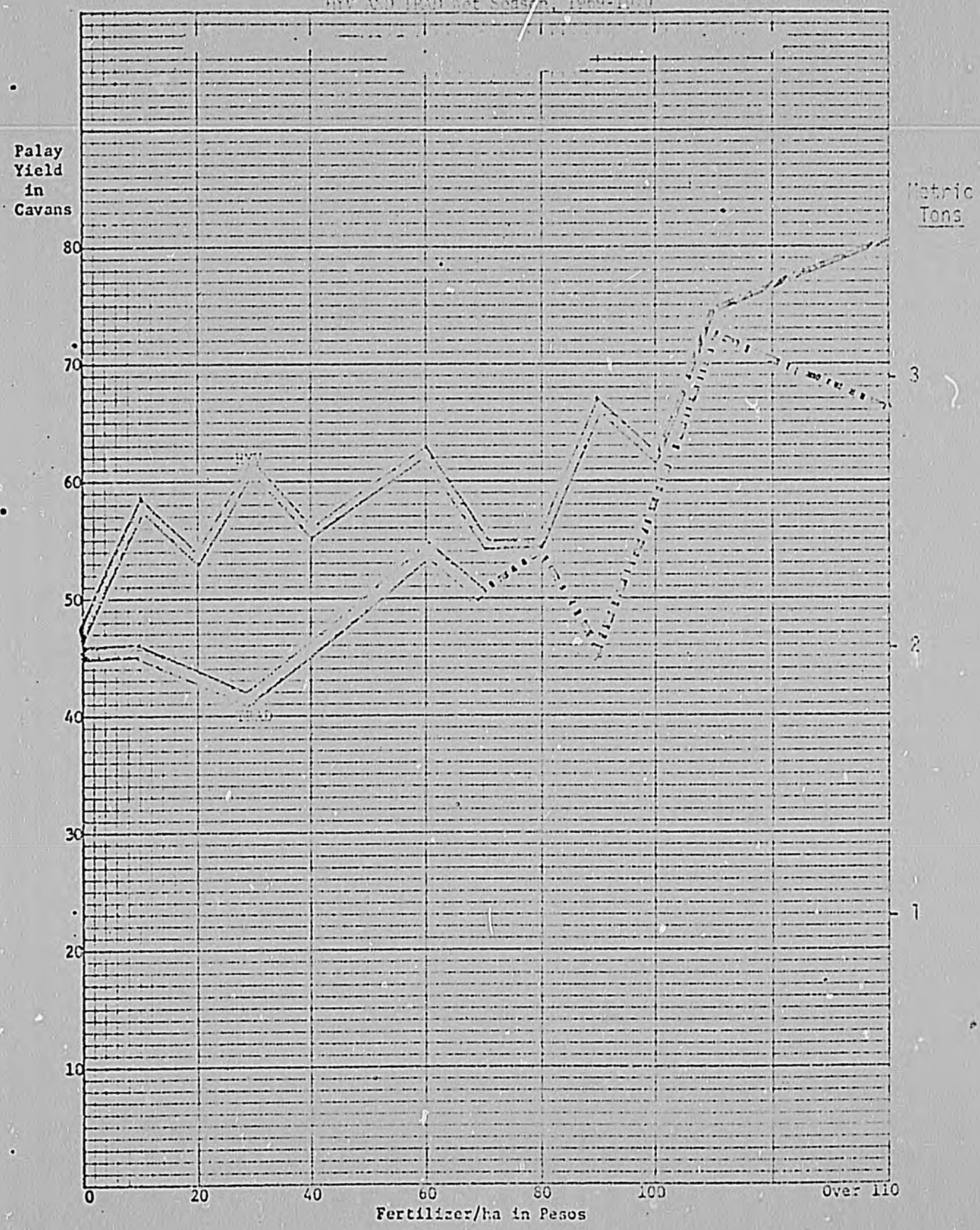


FIGURE 9.--PHILIPPINES: PALAY - FERTILIZER RELATIONSHIPS - HYV
WET AND DRY SEASONS, 1969-1971, (IRRIGATED)

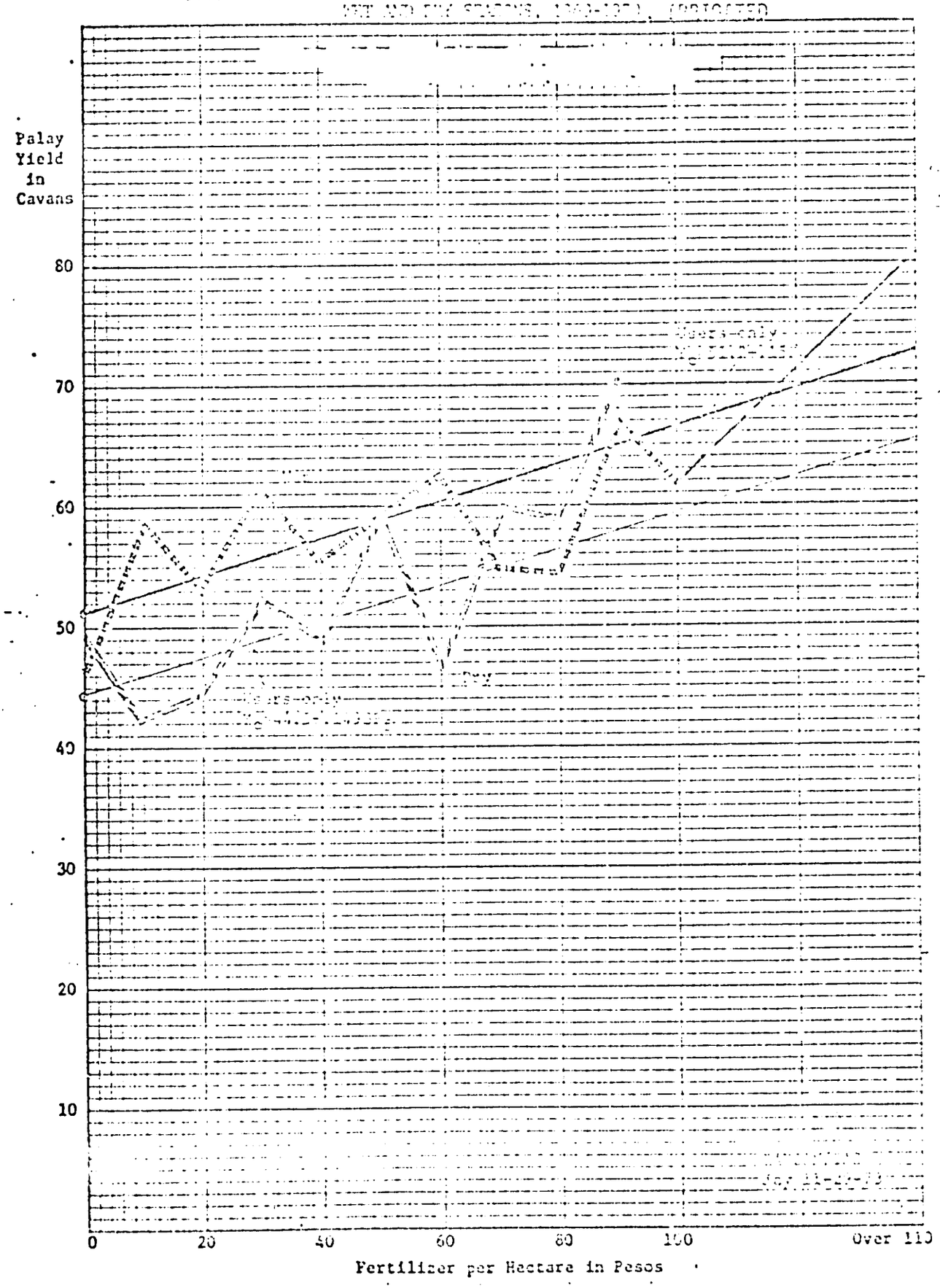
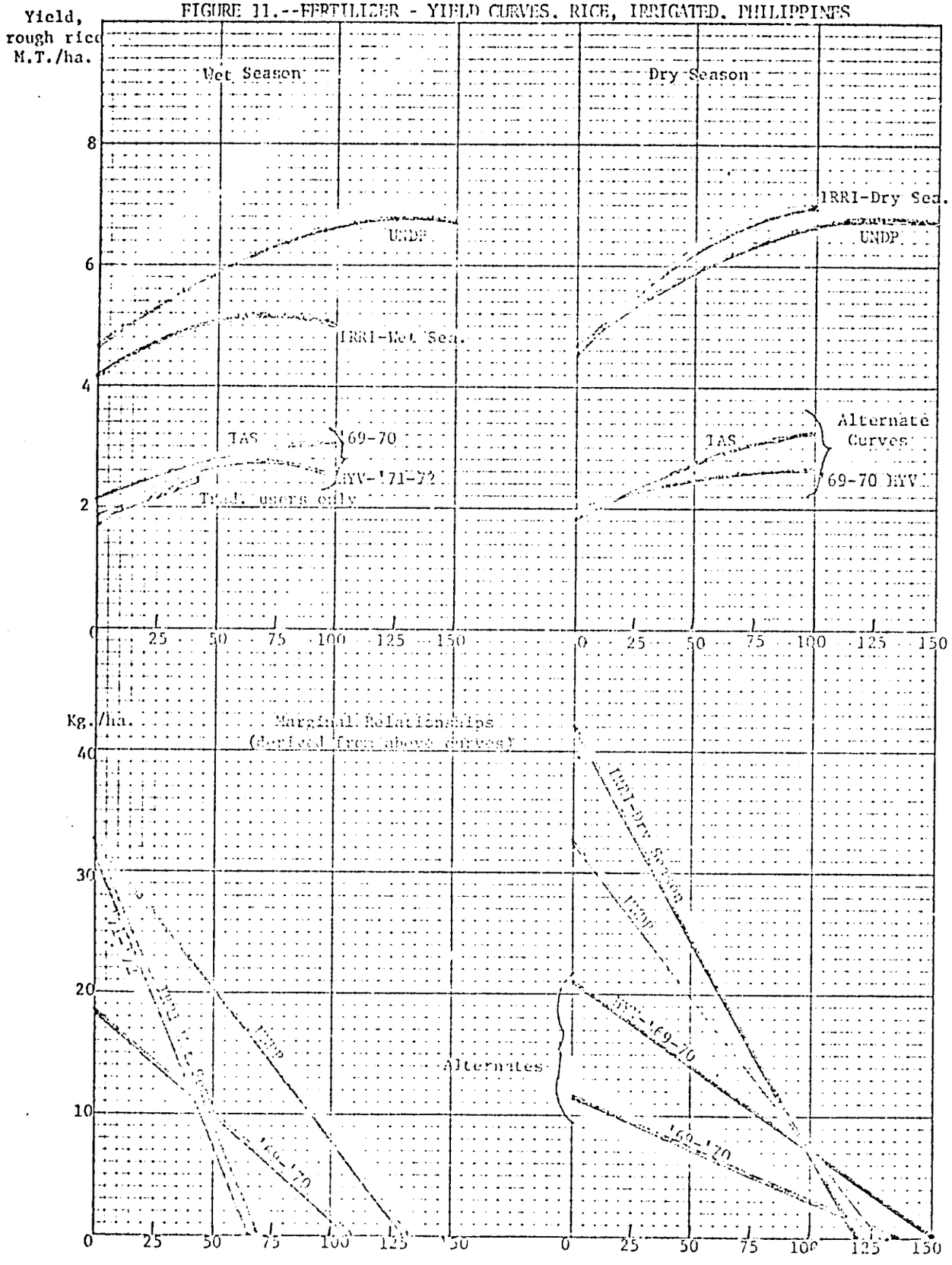


FIGURE 10.--FERTILIZER - PALAY RELATIONSHIP, RAINFED, 1st SEMESTER, HYV AND TRAD

FIGURE 11.--FERTILIZER - YIELD CURVES, RICE, IRRIGATED, PHILIPPINES



Kgs./ha. Nitrogen or Nitrogen plus Phosphorus

Figure 12.--Variability in yield response of IR8 and IR20 to nitrogen by year. IRRI, 1966-72 wet seasons and 1969-72 dry seasons

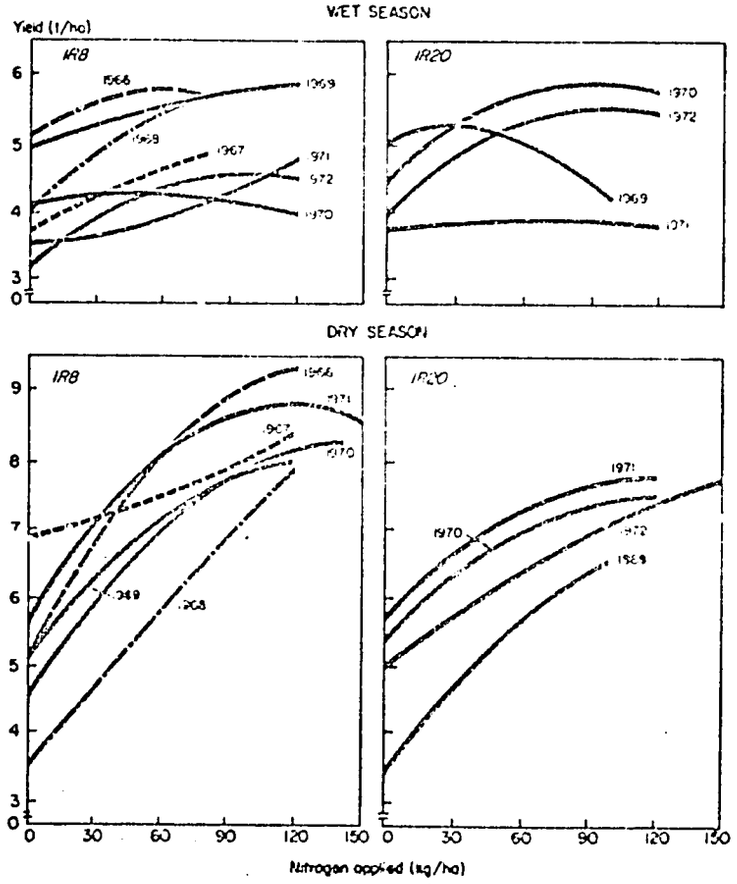


FIGURE 13.--FERTILIZER - RICE YIELD RESPONSE - HYV FARMERS' FIELD, LAGUNA (IRRI) UNDP - PHILIPPINES

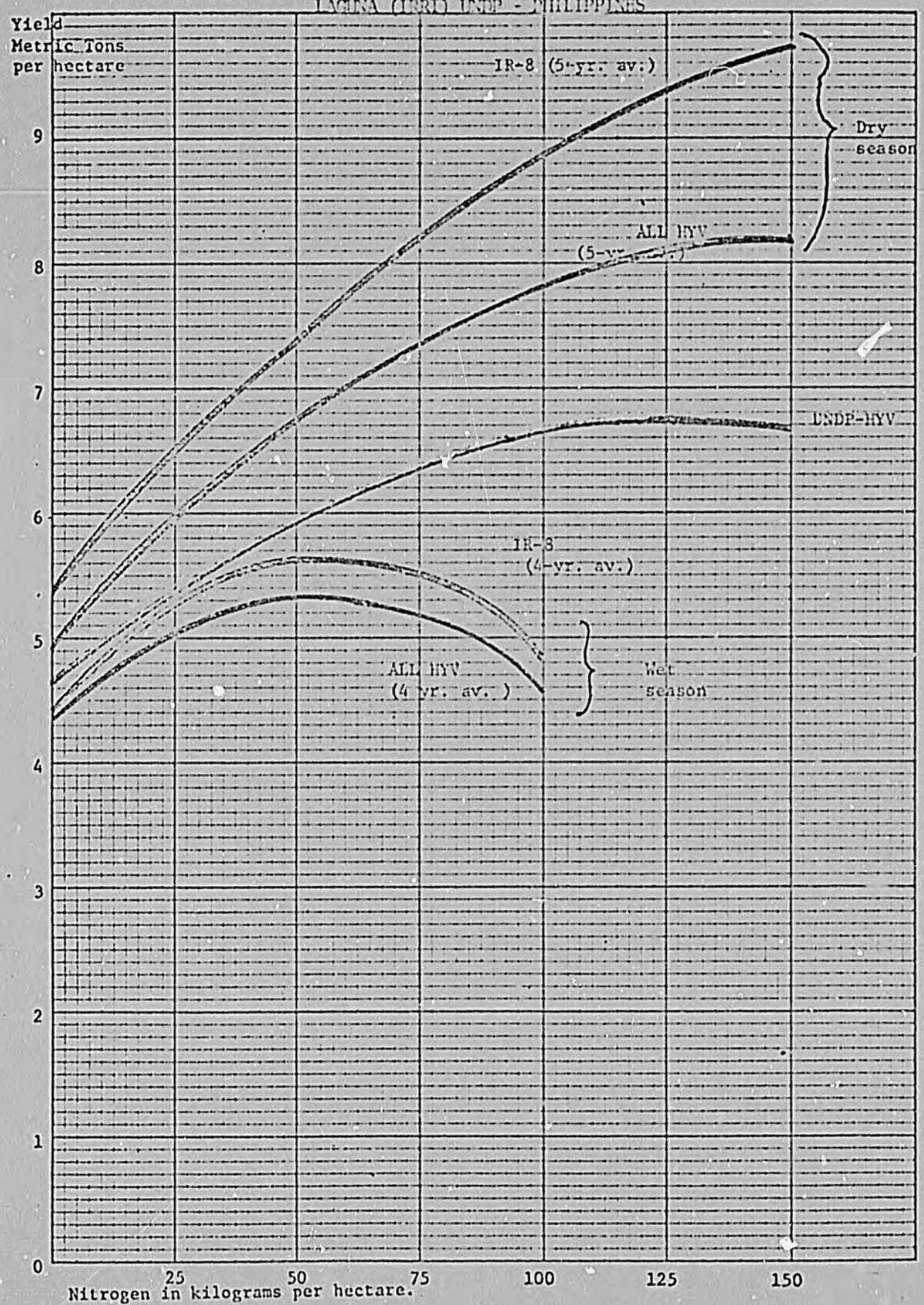
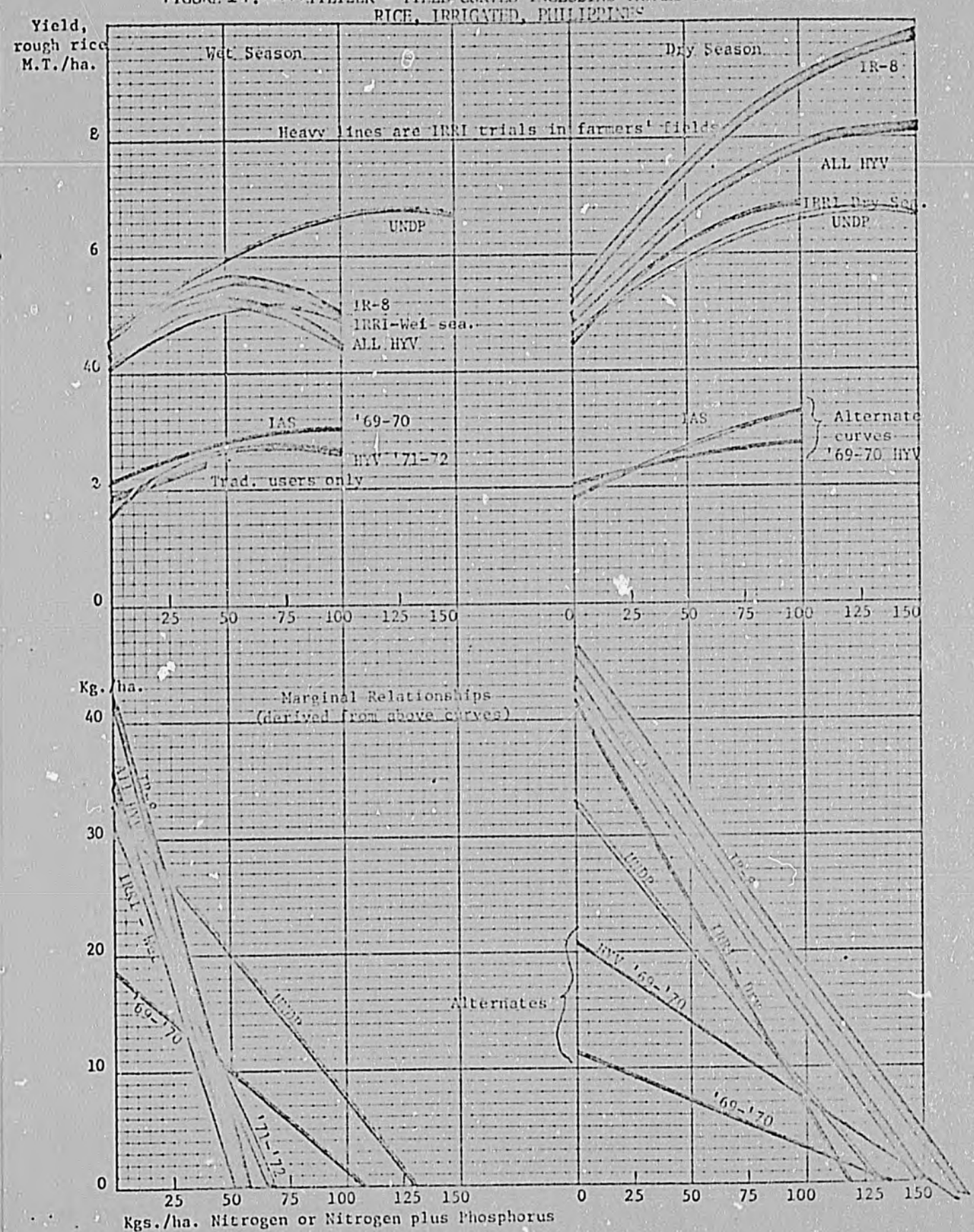


FIGURE 14.--FERTILIZER - YIELD CURVES INCLUDING TRIALS IN FARMERS' FIELDS
RICE, IRRIGATED, PHILIPPINES



Appendix Table 1.--HYV Yield Advantage Calculations

Year	Crop type	Area Harvested: All	Area Harvested: HYV	Area Harvested: HYV	Area Harvested: Other varieties	Yield per hectare: HYV	Yield per hectare: Other	Yield Advantage: HYV less other varieties	Yield Advantage: HYV over other varieties
		1,000 hectares		Percent	1,000 hectare	Kgs.			Percent
1968	Irrigated	1,309	445.1	34.0	863.9	1976	1610	366	22.7
	Rainfed Lowland	1,514	256.4	16.9	1,258	1294	1241	53	4.3
1969	Irrigated	1,483	912.8	61.0	570.0	1778	1619	159	9.8
	Rainfed Lowland	1,407	438.9	31.2	967.9	1126	1091	35	3.2
1970	Irrigated	1,346	826.6	61.4	519.2	2156	1888	268	14.2
	Rainfed Lowland	1,356	527.4	38.9	828.3	1487	1527	-40	-2.6
1971	Irrigated	1,471	985.0	67.0	485.5	2024	1932	92	4.8
	Rainfed Lowland	1,277	580.4	45.4	697.0	1615	1580	35	2.2
1972	Irrigated	1,332	977.1	73.4	354.9	2055	1725	330	19.1
	Rainfed Lowland	1,584	849.7	54.9	698.5	1443	1351	92	6.8
	Irrigated Average								14.1
	Rainfed Lowland Average								2.8

Appendix Table 2.--Calculations of Production Gain From HYV

Year	Crop type	HYV area	Yield gain	Production gain from HYV	Total	Percent added by HYV
		1,000 hectares	Kgs.	1,000 M.T.	1,000 M.T.	
1968	Irrigated	445.1	365	162.5		
	Rainfed	256.4	53	13.5		
		701.5	251	176.1	4563	3.9
1969	Irrigated	912.8	158	144.6		
	Rainfed	438.9	53	23.2		
		1,352	123	167.8	4444	3.8
1970	Irrigated	826.6	268	221.8		
	Rainfed	527.4	-40	20.9		
		1,354	150	201.0	5232	3.8
1971	Irrigated	985.0	92	91.0		
	Rainfed	580.4	35	20.4		
		1,565	70	111.5	5342	2.1
1972	Irrigated	977.1	330	322.4		
	Rainfed	849.7	92	78.5		
		1,827	220	400.9	5100	7.9
	Average					4.3

Appendix Table 3.--Alternative HYV Yield Advantage Calculations

Year	HYV			HYV gain	Based on HYV crop type proportions		Alternative calculation based on actual averages	
	Production	Area	Yield		Other varieties yield all lowland	Yield gain HYV over other varieties	Other varieties yield actual all lowland	HYV yield difference over actual other varieties lowland
	1,000 M.T.	1,000 hectares	- - - - - - Kgs.		- - - - - -	Percent	Kgs.	Percent
1968	1212	701.5	1729	251	1478	17.0	1390	24.4
1969	2118	1,352	1566	123	1443	8.5	1285	21.9
1970	2566	1,354	1896	150	1746	8.6	1668	13.7
1971	2930	1,565	1958	70	1888	3.7	1725	13.5
1972	3232	1,827	1769	220	1549	14.2	1465	20.7
Avg.						10.4		18.8