ANNEXURE 1

ENHANCING RIGOR AND RELEVANCE IN IRRI'S RESEARCH

IRRI Thursday Seminar, 9 January 1986

Dr. M. S. Swaminathan

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I. INTRODUCTION

1985 has been a good year globally for rice production, with unmilled rice production reaching 475 million tons. Indonesia not only became self-sufficient in its rice requirement but generously donated 100,000 tons of rice to the needy people of Africa. There is, however, no time to rejoice or to relax. The available FAO and IFPRI data show that demand will exceed production in 90 developing countries (excluding China) by the end of the century (Table 1).

An important reason for this situation is the continued high rate of population expansion as well as the continued damage to the basic life support systems of land, water, flora, fauna, and the atmosphere. Of the anticipated population of 6.15 billion by the year 2000, about 4.89 billion people will be in developing countries. In fact the population of India is likely to exceed that of China by 2050 if effective measures for population stabilization are not taken (Table 2).

An immediate consequence of such population growth is the heavy pressure on land. The carrying capacity of land in 117 developing countries at intermediate level inputs had been exceeded by 1975 and the pressure by 2000 will be considerable (Table 3).

The need for higher productivity coupled with the need for stable production has led to a large investment in irrigation. Irrigated areas will continue to grow in South and Southeast Asia (Table 4). Irrigated rice culture, which provides more than 80% of the world's rice, should continue to receive adequate attention. For this purpose, IRRI will have to maintain a strong maintenance research program to defend the yield gains already made. Maintenance research in rice is expensive because many new problems constantly arise in the fields of plant protection and soil health care.

At the same time, IRRI will have to tap all relevant upstream technology for solving downstream problems. The most powerful tools of modern science and technology should be utilized to solve the field problems encountered by small farmers. If this is not done, the utility of IRRI to national research systems will tend to diminish. We will have to continue to expand and strengthen our symbiotic links with advanced institutions and universities in developed and developing countries. If you have a little

Table 1. Paddy production-demand balance sheet for 90 developing countries -- FAO-IFPRI data (in million mt)

Period	Production	Demand	Self-sufficiency ratio
1966-70	144.7	142.4	102
1976-80	187.3	185.6	101
2000 Projection			
Trend	309.9	327.9	95
Low Demand	309.9	322.5	96
High Demand	309.9	336.8	92

Table 2. Population Projections: 1980 to 2100 (population in millions)

Selected Countries	1950	1980	2000	2025	2050	2100	Total Fertility Rate-1982	Year in which NRR=1
China	603	980	1,196	1,408	1,450	1,462	2.3	2000
India	362	687	994	1,309	1,513	1,632	4.8	2010
Indonesia	77	146	212	283	330	356	4.3	2010
Brazil	53	121	181	243	279	299	3.9	2010
Bangladesh	44	89	157	266	357	435	6.3	2035
Nigeria	41	85	169	329	471	594	6.9	2035
Pakistan	37	82	140	229	302	361	5.8	2035
Mexico	27	69	109	154	182	196	4.6	2010
Egypt	20	42	63	86	102	111	4.6	2015
Kenya	6	17	40	83	120	149	8.0	2030
Regions								
Developing Countries:								
Africa	223	479	903	1,646	2,297	2,802	6.4	2050
East Asia	587	1,061	1,312	1,542	1,573	1,596	2.3	2020
South Asia	695	1,387	2,164	3,125	3,810	4,172	4.9	2045
Latin America	164	356	535	732	856	921	4.1	2035
Sub-total[a]	1,670	3,298	4,884	6,941	8,400	9,463	4.2	2050
Developed Countries	834	1,137	1,263	1,357	1,380	1,407	1.9	2005
Total World	2,504	4,435	6,147	8,298	9,780	10,870	3.6	

[a]Regional figures do not add to "Developing Countries Sub-Total" due to rounding.
Source: 1950: UN Estimates, Other Years: 1984 World Bank estimates and projections.

Table 3. Carrying capacity of land (117 developing countries) at international-level inputs

Year	Excess population (in million)
1975	76
2000	486

From: "Land Resources for Population of the Future" - FAO.

Table 4. Projected irrigation development in South and Southeast Asia to the year 2000.

Region	Area in million ha 1980	2000	Percent of harvested area 1980	2000
South Asia	55.3	91.9	29	42
Southeast Asia	12.6	19.0	28	29

Source: Asian Development Bank. Agriculture in Asia, 1985.

time to go to Calauan, Laguna, you can see one example of such meaningful partnership. Here, in a farmer's field, Australian scientists from CSIRO and IRRI agronomists are working together using sophisticated measurement techniques to understand how to minimize the loss of fertilizer nitrogen. We are fortunate to have such beneficial collaboration with many outstanding research scientists and institutions in North America and Europe.

The most urgent downstream problems accorded a high priority in IRRI's research agenda are environmentally disadvantaged areas such as rainfed upland and lowland rice areas, deep water rice areas, and problem soil areas. Along with greater attention to difficult growing conditions, there has to be accelerated attention to economically disadvantaged farmers through research on methods of reducing cost without lowering yields. This is where a proper blend of upstream and downstream research will help us to be of maximum assistance to national research systems.

With this background, I would now like to deal with the topic for today's talk, namely enhancing rigor and relevance in our research programs.

I request those reading this paper also to read the last chapter entitled Looking Ahead, which I wrote for our 25th Anniversary publication* based on the seminar I delivered in January 1985. These two papers will be helpful in understanding how we are trying to give content and reality to the recommendations of the last Quinquennial Review and to the policy guidelines provided by our Program Committee and Board of Trustees.

II. ENHANCING RIGOR

A. Experiment Farm

The most important facility in an agricultural research institution is the Experiment Farm. Ultimately, yield under field conditions is the major determinant for the choice of varieties and management practices. In the first IRRI seminar I gave after joining the Institute in April 1982, I stressed the need for understanding the causes for a steady decline in maximum yields on the IRRI farm since the early 70s (Fig. 1). After considerable discussion, a multidisciplinary experiment on maximizing yield was initiated. This experiment is still in progress and it has provided useful insights into the probable causes for the decline. The factors involved include reduced lodging resistance in early maturing varieties, less than optimum crop duration, high boron content in irrigation water, and buildup of pest and disease problems. As a

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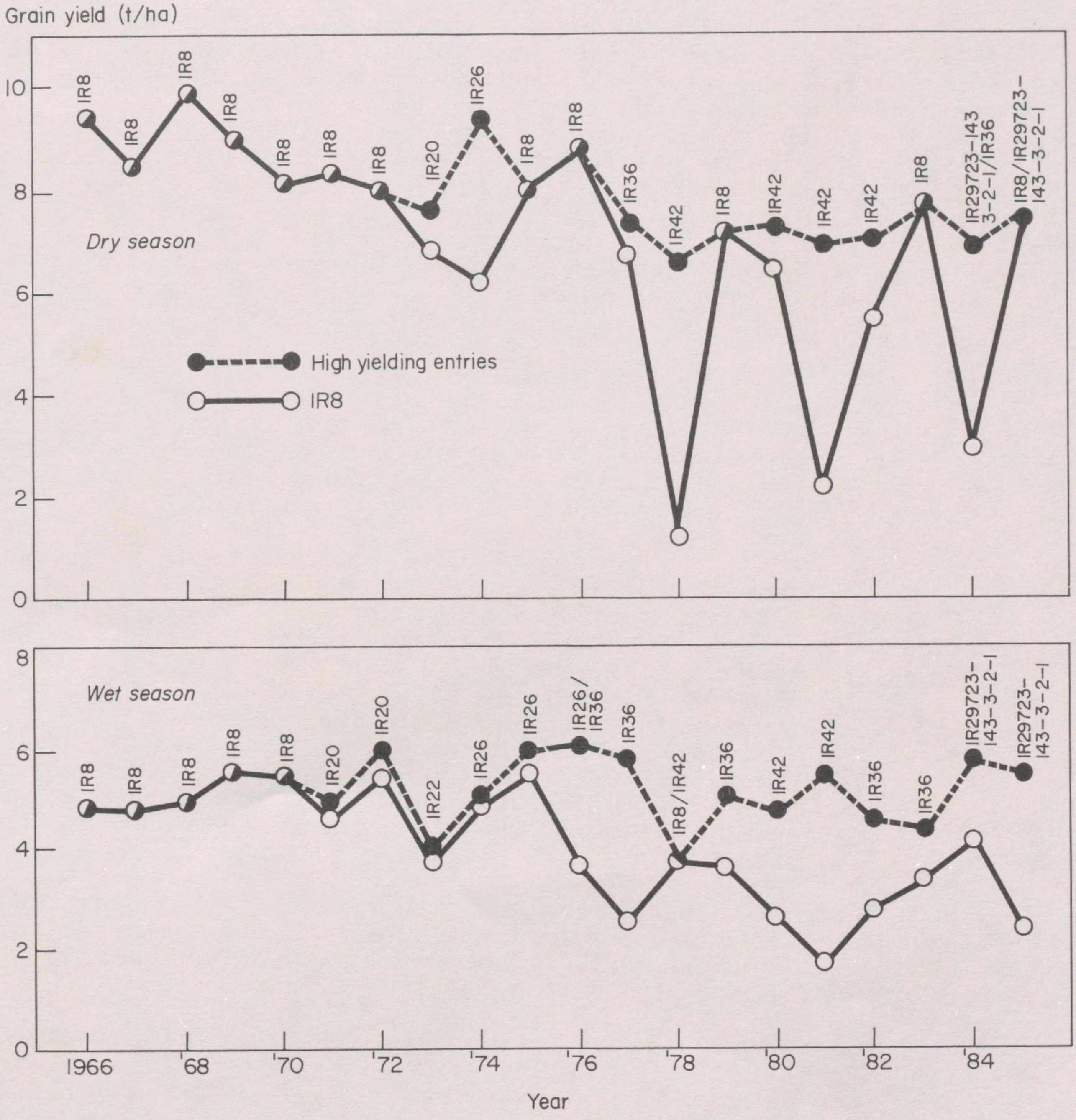
*International Rice Research Institute: 25 years of partnership, IRRI, 1985, pp. 171-188.



1. Yield trends for dry and wet season planting of IR8 and highest yielding entry. Long-term fertility experiment, IRRI farm, 1966-1985.

result of this experiment, several measures for maintaining sustainable levels of high productivity have been taken.

Dr. F. N. Ponnamperuma, who was until the middle of last year the Head of IRRI Soil Chemistry Department, listed the following factors as important from the point of view of maintaining high productivity in IRRI's farm:

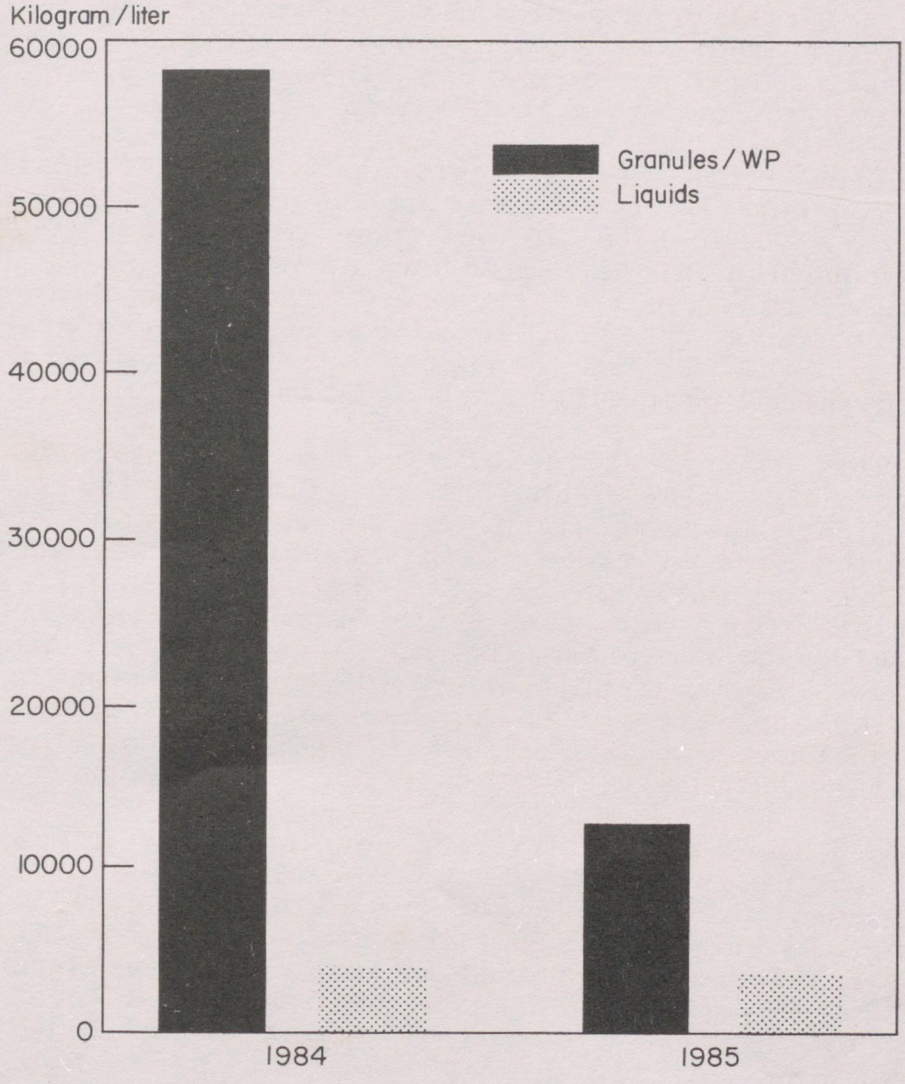
- boron poisoning present in 58 blocks;
- zinc malnutrition, too little Zn in 67 blocks; perhaps too much in 6 blocks;
- widespread N deficiency;
- P deficiency uncommon;
- K and Si surfeit in most blocks; and
- all reservoirs except MI, CS, and CP contain too much B and salt.

The remedial steps taken include:

- attention to drainage to prevent waterlogging during heavy rains and typhoons;
- cleaning of rivers and creeks to destroy the habitat of rats, deepening and widening of canals, and construction of additional culverts;
- development of a method of drilling wells that leads to minimum water contribution from the undesirable aquifer strata; and
- systematic monitoring of the quality of tube well and reservoir waters, particularly for concentrations of B, Si, EC, K, Na, Mg, HCO_3, SO_4 and C_1 and pH value. The high pH values in the tube well waters are responsible for a buildup of high soil pH over the years. This trend has now been reversed by mixing low quality well water with high quality well or stream water and by reducing the temperature of water in the reservoirs.

There is a growing demand from scientists for additional experiment farm area. Thanks to the generous assistance of UPLB, we have been able to get for temporary use nearly 20 ha of additional land during the last 3 years.

Another problem in farm management that has received considerable attention since 1982 is pest surveillance and the monitoring of pesticide use. Year after year the consumption of insecticides is being reduced. There has been a drastic decline in insecticide use on IRRI farm during the last year (Fig. 2). The use of a newly fabricated boom sprayer has further refined insecticide application and enhanced safety through prevention of dispersal by wind. This sprayer, however, presents some problems including greater labor requirement and hence a single nozzle sprayer is being tested on a wider scale. In addition, strict safety measures have been introduced to eliminate pesticide hazards to those who are in charge of applying them in the field. Besides dress regulations, all



2. Insecticide use on IRRI farm 1984 and 1985.

those involved in pesticide spraying have to undergo rigorous training in the safe handling of pesticides. It is exceedingly important that we continue to improve our pest monitoring and management procedures.

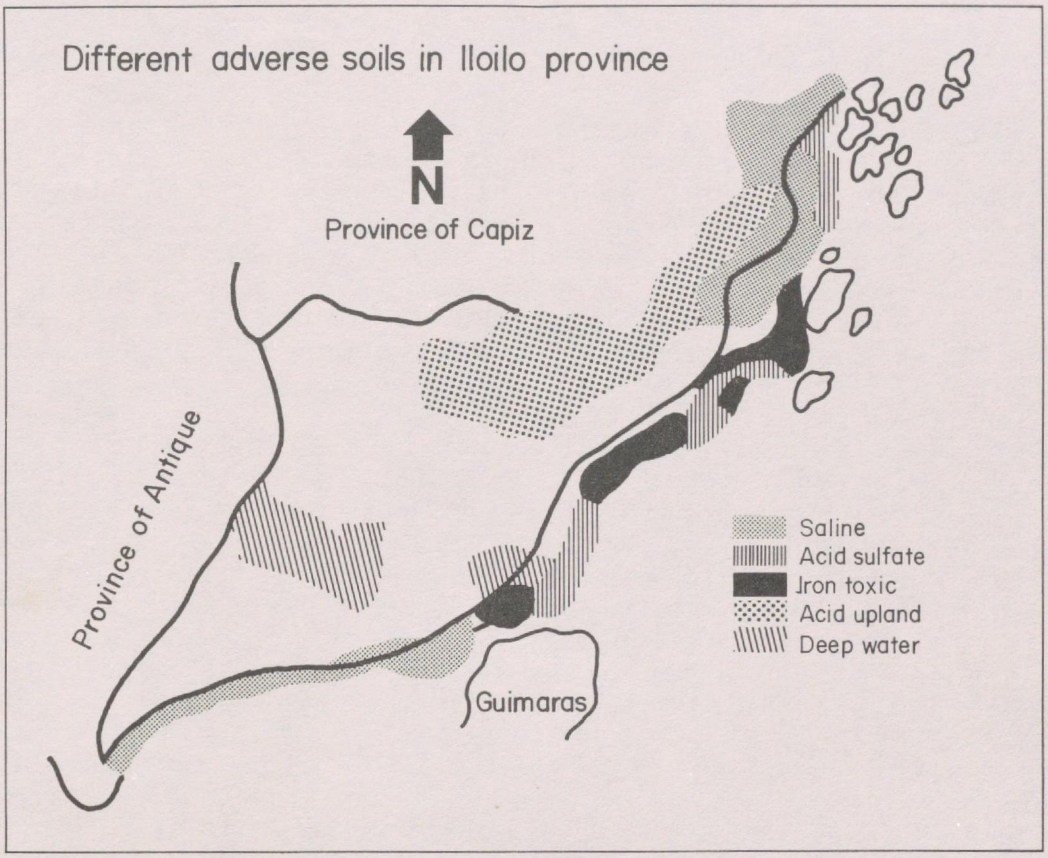
Since the inception of IRRI, the rat menace in the IRRI farm has been controlled essentially with the help of fences energized with batteries. This is an expensive operation and, with the kind help of the Government of New Zealand, a new energy pack and solar energy devices have been introduced. There is as yet no other method of preventing damage by birds except with the help of bird boys.

In the field of nutrient supply, Azolla application offers potential for reducing dependence on mineral fertilizer. Therefore in all nonexperimental fields and seed production plots, the use of Azolla as a partial substitute for mineral fertilizer is being introduced. Steps are being taken to promote _in situ_ conservation of biomass in the fields through the control of grazers by using botanical pesticides such as neem cake.

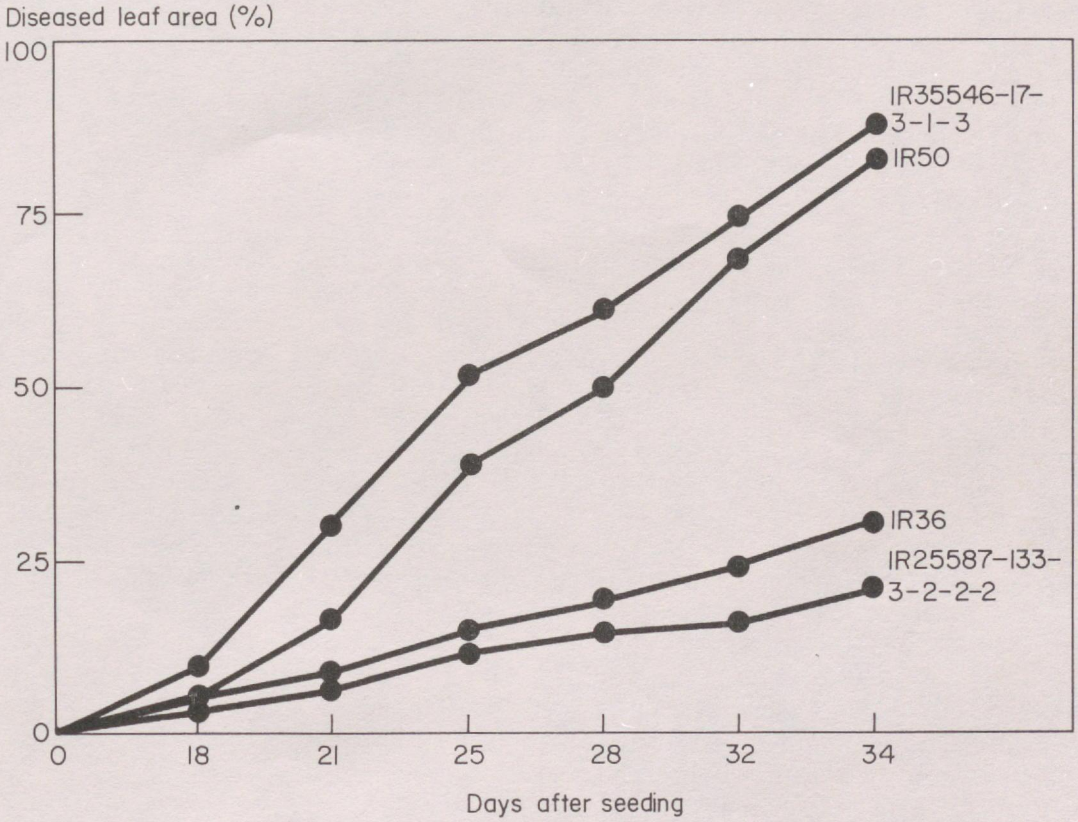
IRRI's classification of rice growing environments was published in 1984 (Khush and Garrity 1984). This publication has received wide appreciation. Having articulated the various target environments that need scientific attention, it is important that we have facilities for screening breeding material and for undertaking agronomic experiments in areas representative of major rice growing conditions. A recent addition to IRRI's facilities for research on adverse soils is the development of _hot spot_ screening locations in Iloilo for different soil constraints (Fig. 3).

Among the other facilities developed for improving the rigor of experiments, I would like to mention the establishment of a blast nursery with good facilities for studying the development of disease epidemics. More than 125,000 entries were screened in 1985. Because the beds can be easily irrigated, we can maintain specific races in the nursery by year round sowing of a particular variety. For example, the upland variety UPL Ri5 previously showed complete resistance in the nursery in that no typical sporulating lesions were present. In 1985, however, we found isolates from farmers' fields that could cause disease on UPL Ri5. We are using this variety to maintain this race in the nursery. Infected UPL Ri5 seedlings are now a source of part of the inoculum mixture used in our screening work.

The blast nursery also allows us to do more detailed evaluations of the GEU elite lines, so that their level of partial resistance can be compared to well characterized varieties such as the susceptible IR50 and the partially resistant IR36 (Fig. 4).



3. Adverse soils in Iloilo, Philippines.



4. Blast nursery test for partial resistance.

In addition to the blast nursery, seven additional screenhouses and insect houses have been constructed. Permanent beds have been laid out for facilitating hybridization work. Also, several deep water tanks have been constructed to develop higher yielding and pest resistant material of deep water rice for testing in Thailand, Vietnam, Bangladesh, Burma, India, and all other areas where deep water rice is cultivated.

B. Laboratory facilities

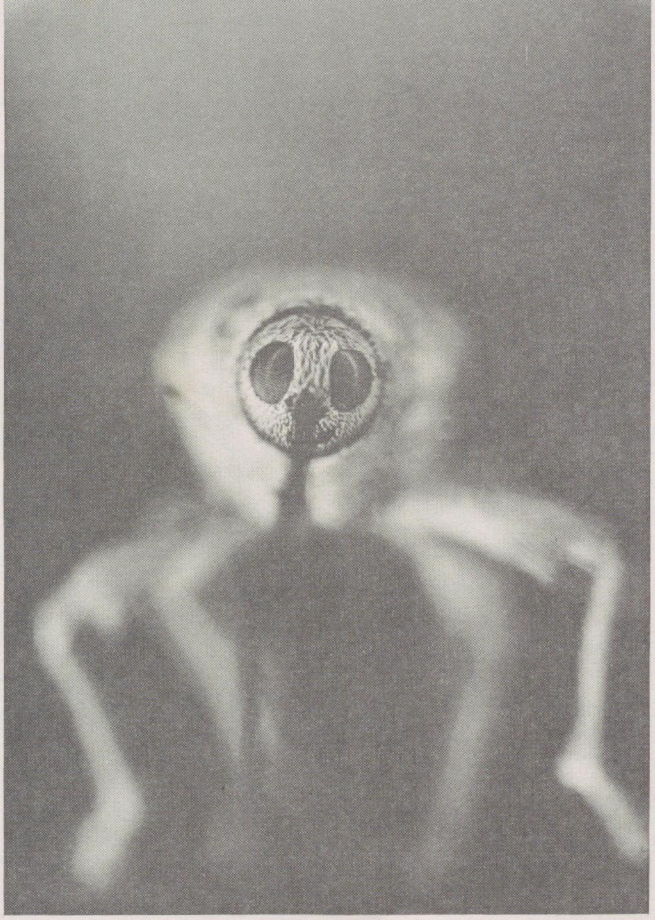
Among the significant new facilities created for laboratory work, I would like to refer to the new micro- and macrophotography laboratory set up with generous assistance from Eastman Kodak Co. through USAID. Pictures taken with the new scanning photomacrographic equipment allow very high quality resolution. Only about 12 such pieces of equipment exist in the world today. Figures 5 and 6 show the difference in resolution between conventional photomacrographic and scanning photomacrographic techniques.

Another important facility is the electron microscope laboratory (EM), set up with kind help from the Government of The Netherlands, which houses the Philips EM 410 Transmission Microscope (TEM) and Philips SEM 505 Scanning Microscope (SEM).

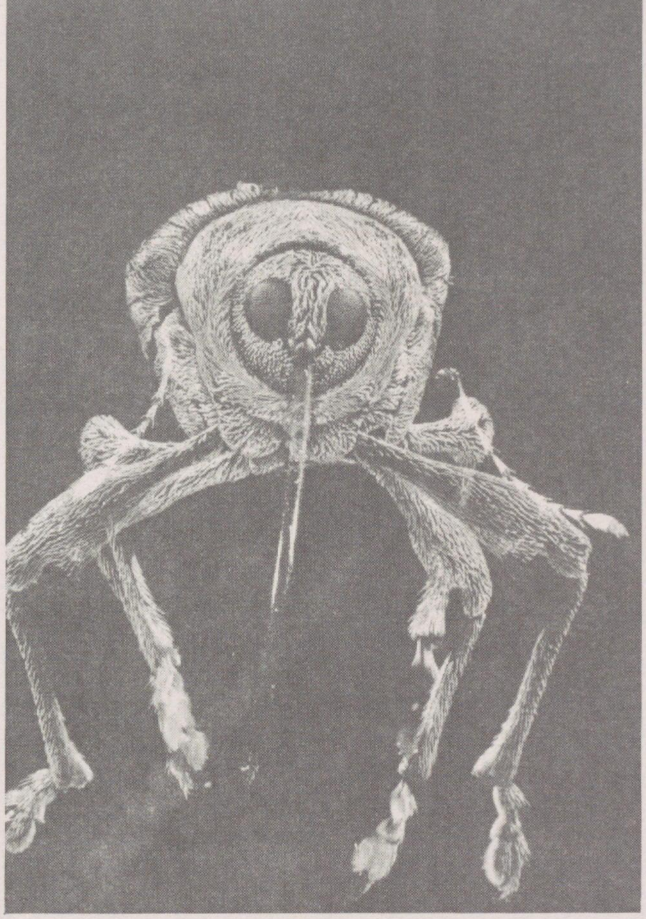
By using the EM, tungro disease was found to be a complex caused by two kinds of viruses: rice tungro bacilliform (RTBV) and rice tungro spherical (RTSV) viruses. Properties of the viruses were studied by using the microscope and the viruses were purified from infected plant extracts. Antisera were obtained by injecting the purified RTBV and RTSV into rabbits, and serodiagnosis techniques were developed.

Since the establishment of facilities for serodiagnosis techniques, the quality of research on tungro has improved and some new approaches have been made. Previously, RTV diagnosis was based on symptomatology or occasionally by transmission test. Diagnosis based on symptoms is not always reliable, and the transmission test is time consuming. Also these techniques could not differentiate plants infected with either RTBV or RTSV, or both. Serology helps to detect RTBV and RTSV in a leaf sample in a relatively short time. By collecting and mailing dry leaf samples, diagnosis of the disease occurring in remote areas can be made.

Since 1982 the Institute has undergone a very rapid growth in its computerization program. Progress has been particularly rapid since June 1983 when the IBM Company kindly donated an IBM 4331 system to IRRI. In 1985, IRRI upgraded the system to a larger IBM 4361. This modern computing facility now provides scientists with direct and immediate access to data via display terminals. With the



5. Photo of Acorn weevil Balanius sp. taken by conventional photomacrography. (© 1978, Darwin Dale)

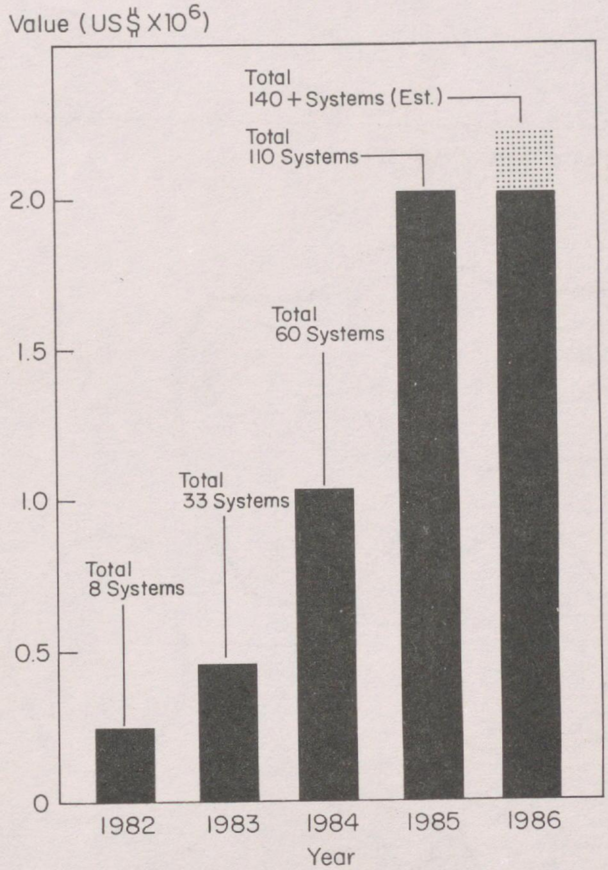


6. Photo of Acorn weevil Balanius sp. taken by scanning photomacrography. Image sharpness is increased 500 times. (© 1978, Darwin Dale)

use of powerful software packages for reiterative analysis together with program and data base development, work is now being performed in minutes where it would have taken several days before. The mainframe computer is being linked with the microcomputer network. The rapidity of growth in the entire computing system is shown in Figure 7. The enhanced capacity from the IBM 4361 system can be seen from the data in Table 5.

Facilities for computer-aided instruction have been created in the new Training and Technology Transfer building constructed with generous assistance from the Government of Japan. Many innovative changes have been introduced in our techniques of transferring knowledge and skills. The Communication and Publications Department has moved into an integrated system of computerized word processing and phototypesetting. In 1985 IRRI editors began to edit publications electronically on the computer screens. Interfacing of the disks with our phototypesetting unit eliminates redundant keyboarding and allows faster turnaround. For example, computerization contributed to the release of the 1984 Annual Report in October 1985--the earliest in at least a dozen years.

Computerization is being introduced in field operations. It is our hope that during 1986 many aspects of administration including personnel data, motor pool management, purchase of equipment and supplies, and accounting will also be computerized. About 150 persons have been given computer training in house. The new system has allowed us to commence building a computer network connecting all departments (Fig. 8). During 1986 we plan to connect our system to an overseas computer network via communication satellite. In the immediate future we hope to link our system with that of the Asian Institute of Technology in Bangkok (Fig. 9). It is obvious that we are entering into an altogether new world of possibilities in communication, data base management, and information retrieval and transfer. We organized a workshop on the use of microcomputers and we should maintain our lead in the field of computer applications to crop improvement research. While we are expanding our computer hardware, high priority will have to be given to software development. Shortly, we will be establishing an integrated software library. At the same time, we are taking steps to enlarge the meaningful applications of computer technology to rice improvement. For example, in collaboration with the Centre for Agrobiological Research and the Department of Theoretical Production Ecology, Wageningen, The Netherlands, IRRI is involved in organizing a training course on Systems Analysis and Simulation for Rice Production from September 1985 to January 1987. The classroom portion of the course will be carried out at Wageningen from January to April 1986.

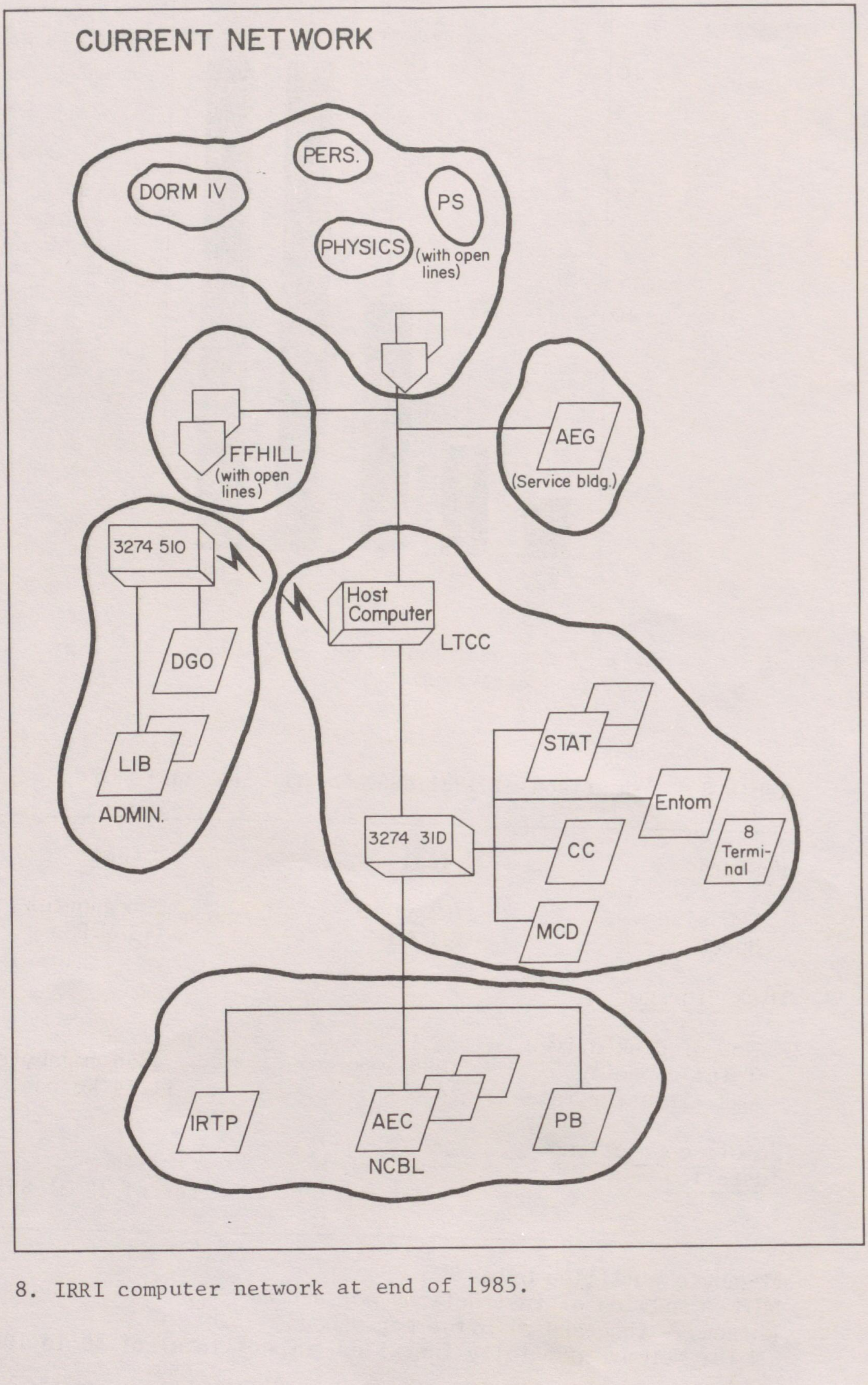


7. IRRI computer purchases 1982-1985; 1986 purchases estimated.

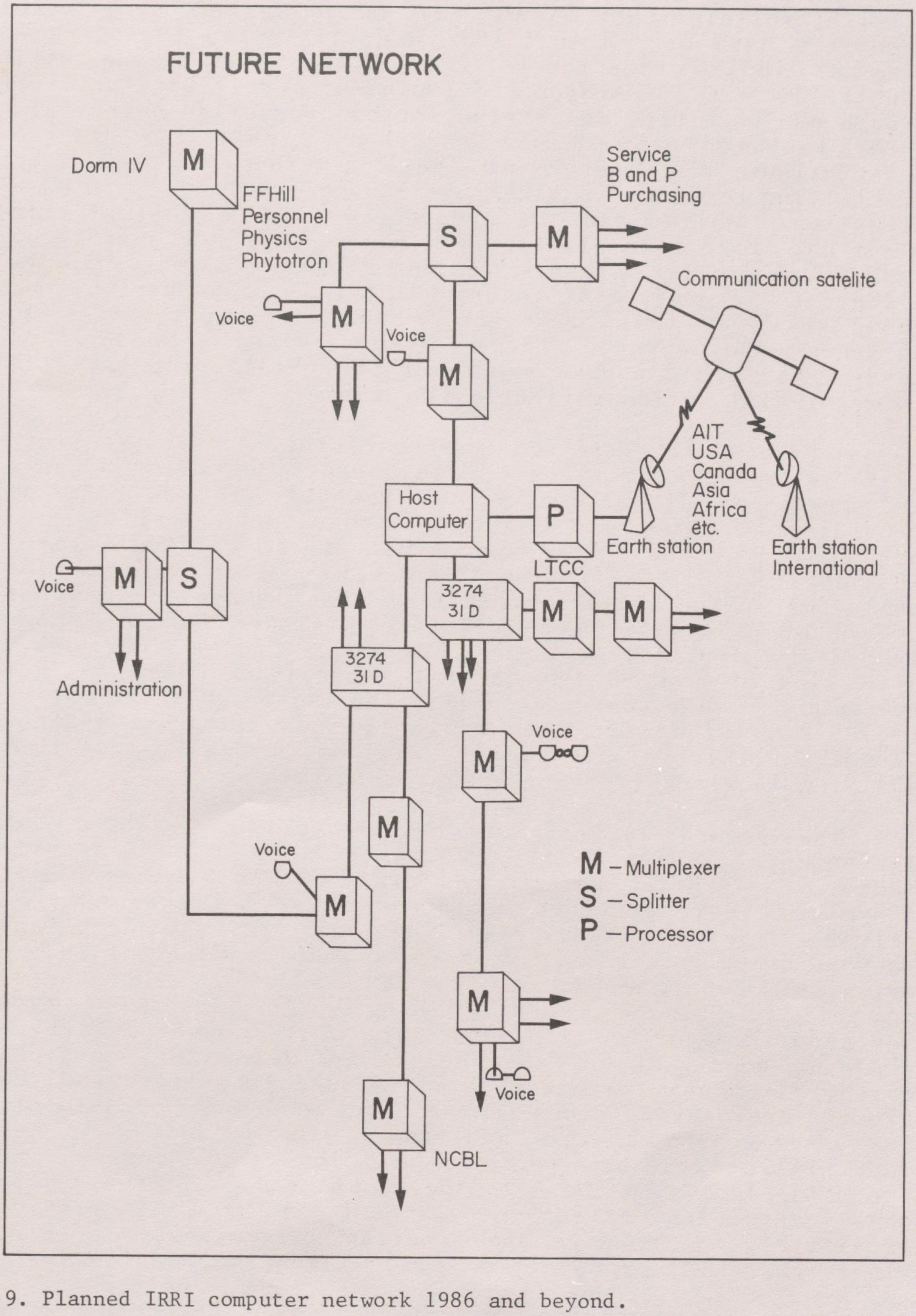
Table 5. Comparison of IRRI 4331 Group I and 4361 ML5

Feature	4331	4361
CPU size	1 megabyte	12 megabytes
Speed	.19 MIPS	1.3 MIPS
Disk storage		
No. of disk drives	4	8
Total capacity	1280 megabytes	4556 megabytes
Max. transfer rate	7436 kb/sec.	11154 kb/sec.
Remote connections installed	6	15 (as of 12-31-85)*

Megabyte = million bytes
MIPS = million of instructions per second
kb/sec. = thousand of bytes per second
*Note: Network not fully installed; expect total of 40 in 1986



8. IRRI computer network at end of 1985.

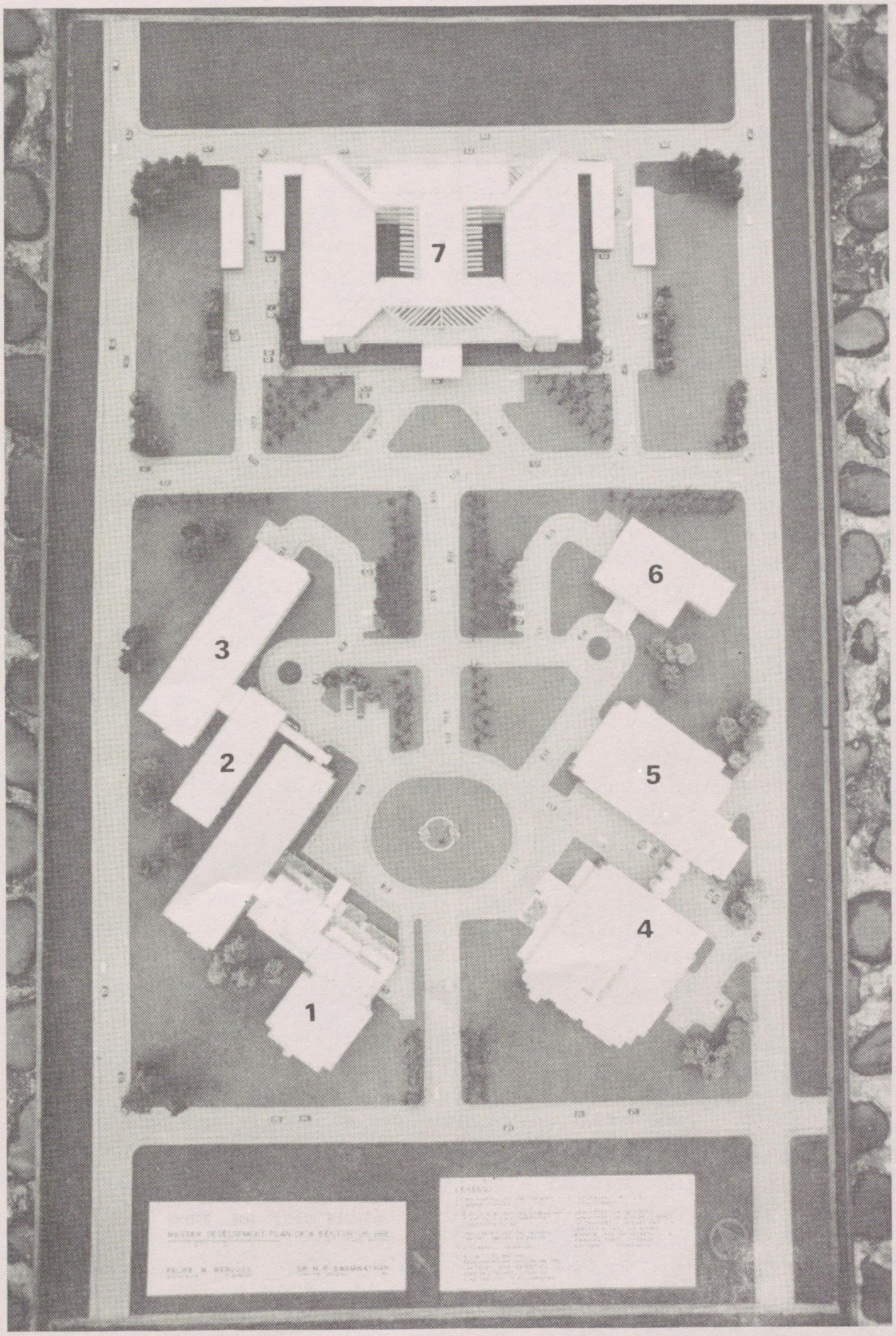


9. Planned IRRI computer network 1986 and beyond.

Interdisciplinary teams of scientists from seven countries have been identified to participate, including a team of junior researchers from IRRI. The course will enable the team to develop and implement models of rice crop growth and use these for evaluation of production potentials under various environmental conditions, pest and disease infestations, and management tactics. The teams will be identifying problems in rice research relevant to their home situation, which can be addressed through simulation modeling. Each team will carry out a joint study during the year after their return from Wageningen. A workshop is planned for January 1987 to bring the teams together to show the results of their research. Funds for the course and workshop are covered by a grant of The Netherlands Government. This course represents an outstanding exercise in meaningful collaboration in the area of training.

I have so far referred to some of the steps taken since 1982 to improve the rigor of field experiments and enhance the power of laboratory work. However, the problem of providing much needed additional laboratory facilities to our scientists and scholars remains. It is difficult for a relatively old institution like IRRI to get funds for buildings. Nevertheless, thanks to the kindness of many of our donors, we have been fortunate to improve some of our laboratory facilities. The IRRI Soils Laboratory, built with kind help from the Federal Republic of Germany, now accommodates the physics unit, the soil organic matter project, rainfed rice agronomy unit, and the rice weather group. Within a few months after occupation, this building is already overcrowded.

The second facility we built was the Training and Technology Transfer Center (TTTC) to which I have already made a reference. We are grateful to the Government of Japan for their generous assistance. TTTC is becoming an extremely valuable facility. At our request, Architect Mendoza prepared a master plan for possible additions to the existing N.C. Brady Laboratory (NCBL) and LTCC laboratories as well as for other new buildings. An outline of this master plan is shown in Figure 10. At the moment, we have funds to construct only one portion of the LTCC expansion, which will house the electron microscope laboratory and the genetic engineering group of the Plant Pathology Department. The construction of this additional wing to LTCC has been made possible through generous help from the Government of The Netherlands and the Asian Development Bank. We are also constructing an extension to NCBL which will provide facilities for improving seed health and quarantine, IRTP, electrophoresis, innovative plant breeding, and tissue culture. The tissue culture and the electrophoresis laboratories, plus the Rockefeller Foundation-sponsored genetic engineering project laboratories, will constitute the biotechnology wing of the NCBL extension. I must record our gratitude to IBM, the OPEC Fund, the Governments of



10. IRRI master development plan.

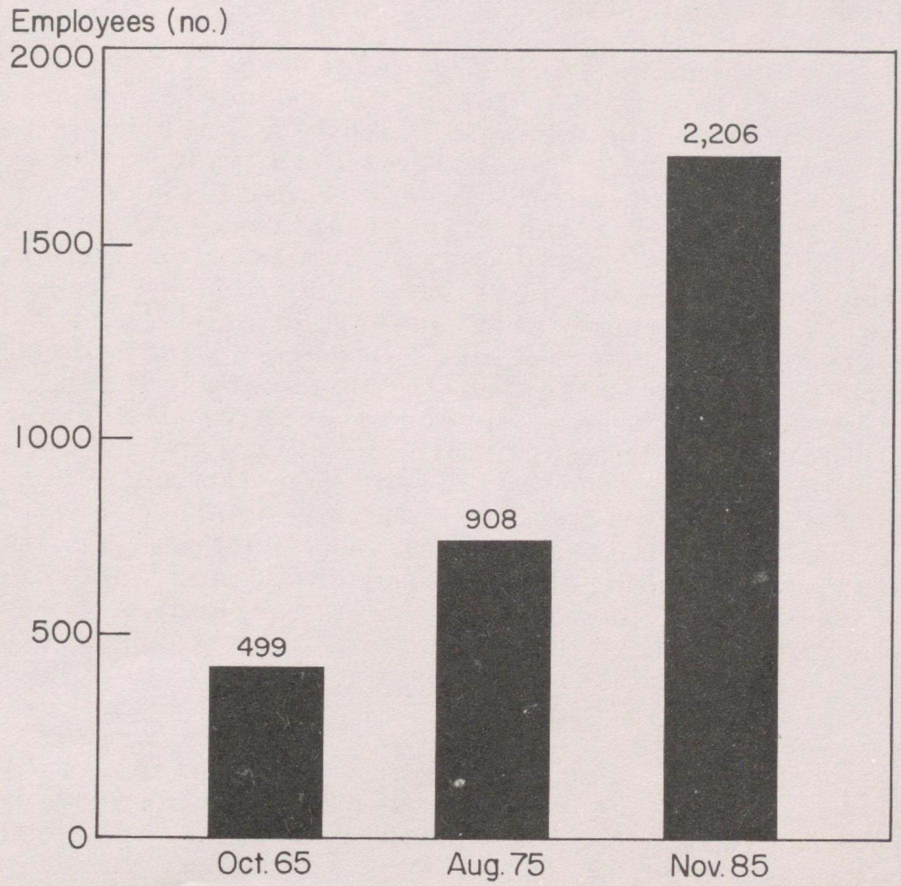
China, India, and Italy, and The Rockefeller Foundation for their help in getting the NCBL extension constructed.

In the plan in Figure 10, two additional buildings are shown for possible construction in future years. One building, #6, is intended for recombinant DNA technology, DNA libraries, and preparation of molecular linkage maps. I hope that IRRI will soon acquire the capability for doing such sophisticated gene transfer and DNA hybridization work. This will be extremely helpful to move genes across sexual barriers. We have a comparative advantage in this area of research because of our vast germplasm bank which includes many precious wild *Oryza* species and other material. Architect Mendoza has also expressed his hope that someday the administrative offices from Chandler Hall can be moved to a new building along with the printing press and other facilities. This building is marked no. 7 in the figure. When this happens, Chandler Hall will also become available for additional laboratories and training activities. These are hopes for the future.

We have enlarged our residential facilities. Six flats and two houses have been added to the units already available in the Staff Housing area. In addition, we have created additional lodging for postdoctoral fellows in the Drilon Apartments.

Our major aim in promoting the pathway of development of farm and laboratory facilities I have so far outlined is to continue to assist our scientists--senior and junior--to give their best to IRRI and the rice world. From the point of view of management, we can only improve our facilities for careful and critical work. It will depend upon the dedication and ingenuity of scientists on what use is made of such facilities. I must say that I am extremely happy with the excellent use being made of these facilities.

One area of concern is the continuous growth in staff strength. The number of IRRI employees has risen by more than 400% in the last 20 years (Fig. 11). A considerable proportion of the increase in the last 10 years is in professional staff strength. In addition to outstanding senior scientists, we are fortunate to have a large number of junior researchers who constitute the backbone of the Institute. However, we should not hereafter expand staff but should concentrate on getting the best of the staff already available. The Chairman of our Board of Trustees, Prof. Kenzo Hemmi, rightly stressed in his lecture at our 25th Anniversary Symposium the need for consolidation. I fully share this view. Even now, there is a tendency for scientists to do more and more work on their own and less and less together. We should arrest this trend and ensure that we have a critical mass of interdisciplinary research capable of solving complex field problems speedily and surely. The GEU program is an outstanding example of the



11. Growth in IRRI staff Oct 1965-Nov 1985.

power of multidisciplinary research, and I attach the greatest importance to a further strengthening of such meaningful interdepartmental research.

III. ENHANCING RELEVANCE

In the beginning of the year seminar in January 1985, I referred to the steps taken to modulate our research priorities to suit the changing needs of national research systems. In particular, I referred to issues in ecology, economics, employment, equity, and energy use to which we are giving increasing scientific attention. Today I wish to refer to three major challenges we now face in promoting the production of rice as well as other food crops on an ecologically and economically sustainable basis. These are in the areas of <u>conservation</u>, <u>commerce</u>, and <u>consumption</u>. Increasingly the basic agricultural assets of land, water, flora, fauna, and the atmosphere are being threatened with different forms of damage. Both domestic and international trade are being affected by low prices for output and high prices for inputs. The main characteristics of international markets for most agricultural commodities during 1985 were ample supplies, weak demand, and declining prices. Inadequate purchasing power is leading to millions of people going to bed hungry. A global foodgrain reserve of more than 300 million tons and more than 300 million hungry people co-exist today.

While the poor are suffering from undernutrition and malnutrition, the dietary habits of the rich reveal rapid changes. The well-to-do of both developed and developing countries are reducing their consumption of basic staples and shifting to what I term <u>health foods of the future</u>. These include salad vegetables, fruits, fibrous material, and processed foods.

How are we going to help the small farmers in rice growing areas meet the triple challenges of conservation, commerce, and consumption? How can we assist national research systems to help their countries promote sustainable livelihood security in rice farming areas? <u>The only way we can achieve our aim is through an intensification of our work in the development and spread of knowledge-intensive production systems</u>. The famous economist, Dr. Theodore W. Schultz, has frequently emphasized the potential of agricultural research to substitute for land and capital. Agricultural research can augment the supply of scarce land and contribute substantially to the secular reductions in real costs of producing food, as IRRI's research has so clearly demonstrated.

The triple goals of a knowledge-intensive production system are:

- Promote the use of farm-grown inputs and reduce the dependence on inputs based on fossil fuel feedstocks.

- Maximize the returns from the available labor land, water, and financial resources.
- Pay concurrent attention to achieving a continuous improvement in the productivity, profitability, stability, and sustainability of rice production systems.

Some areas of research relevant to the development of knowledge-intensive production systems are the following:

- Transdisciplinary research, e.g., integrated pest management, integrated nutrient supply, scientific water use, biotechnology
- Blending traditional and frontier technologies, e.g., agricultural refineries designed to produce value-added products from agricultural biomass
- Farming systems research--technological and socio-economic aspects
- Linkages with international data banks through advanced computer and telecommunication systems for up-to-date data on trends in weather, yield, prices, trade, and research.

IV. CONSERVATION

The following statement by B. F. Skinner should be kept in view by all scientists engaged in developing new production techniques:

> "Every new source from which man has increased his power on earth has been used to diminish the prospects of his successors. All his progress is being made at the expense of damage to the environment which he cannot repair and cannot foresee."

Globally, developing countries in particular face serious problems of denudation of forests, loss of genetic resources, loss of crop land, soil erosion, and desertification. The key environmental pollution problems include CO_2 concentration, trace gases, air pollution, acid rain, water pollution, and hazardous wastes.

An underlying cause for many of these problems is the rapid growth in population since World War II. In October 1985, thirty-five heads of states of both developing and developed countries gave a memorandum to the Secretary General of the United Nations. I wish to quote a few sentences from this document:

> Mankind has many challenges: to obtain a lasting peace between nations; to preserve the quality of the environment; to conserve natural resources at a sustainable level; to advance the economic and social progress of the less developed nations; and to stabilize population growth.

At present there are 76 million more births than deaths on our planet each year. If present rates continue, by the year 2000 there will be 100 million more births than deaths. A billion people have been added in the last 13 years and the next billion will be added in 12 years.

Ecological journals continually publish alarming reports on the consequences of the environmental damage now taking place on an unprecedented scale particularly in developing countries. The African food crisis is in part a result of such damage.

What are IRRI's research programs in the conservation field that need further strengthening? Some of the important ones are:

- germplasm collection conservation with priority going to wild species and strains,
- genetic evaluation and utilization, with greater use of a global grid of hot spot screening sites established under the UNDP-supported International Rice Testing Program (IRTP),
- integrated pest management,
- integrated nutrient supply,
- scientific water management,
- soil health care on a systems basis,
- farming systems research based on integrated principles of ecology and economics, and
- energy efficient farm machinery and equipment.

Recent advances in molecular biology and genetic engineering are opening up unusual possibilities for transferring genes from wild species to cultivated ones. IRRI has therefore intensified its work on the collection of wild species and strains, particularly from endangered habitats. Grants from the International Board on Plant Genetic Resources have made it possible to assemble about 14,016 seed samples from Asian countries and Madagascar. A new headhouse and nursery was built during 1985 to provide additional facilities for growing wild rices; 859 strains of wild rices were cultivated in this screenhouse last year.

The data in Tables 6 and 7 bring out clearly the importance of wild strains and species. The wild species of *Oryza* and a few ex-members of the genus are being recognized as important, or sometimes the sole source of resistance/tolerance to biotic/edaphic stress factors. For instance, *Sclerophyllum coarctatum* (formerly *O. coarctata*) is tolerant of salinity. Since this species is a tetraploid with 2n=48, we are trying to get androgenic haploids through anther culture, so that crosses with *O. sativa* can be made at the same chromosome number level (i.e., 2n=24). Novel sources of resistance to the ragged stunt virus were found in *O. alta*, *O. brachyantha*, *O. latifolia*, *O. minuta*, *O. officinalis*, *O. punctata*, and *O. rufipogon*. Tolerance to

Table 6. Contrast between the sources of resistance to insect pests of wild rices and cultivated strains.

Pest	Accessions tested (no.)		Accessions resistant %	
	Varieties	Wild rices	Varieties	Wild rices
Whitebacked planthopper	47,089	449	0.83	46.3
Brown planthopper				
Biotype 1	45,122	446	0.93	45.7
Biotype 2	15,068	445	1.88	37.8
Biotype 3	16,402	448	1.76	39.7
Zigzag leafhopper	2,383	422	1.51	51.7
Green leafhopper	48,961	447	2.60	53.4
Yellow stemborer	22,920	322	0.11	21.7

Source: IRRI

Table 7. Wild species of *Oryza* with useful traits

Wild species	Useful trait
O. perennis	Tolerance to stagnant flooding and acid sulphate soils
O. nivara	Resistance to grassy stunt virus and blast
O. officinalis	Resistance to BPH, WMBPH and GLH
O. australiensis	Resistance to BPH and drought
O. barthii	Resistance to bacterial leaf blight
O. longistaminata	Floral characters for out pollination
Sclerophyllum coarctatum	Tolerance to salinity

RGSV (grassy stunt) has been found in a Chinese interspecific hybrid (Guan-keng A/O. longistaminata). Among the recently tested insect pests, resistance to thrips has been identified in O. officinalis, O. eichingeri, O. minuta and O. nivara. O. brachyantha is the most resistant source to the whorl maggot. Several O. eichingeri accessions of East Africa have multiple resistance to brown planthopper biotypes 1, 2, and 3, the GLH, WBPH, and yellow stemborer. Varieties collected from Bangladesh and Sri Lanka were found to have resistance to leaffolder and thrips.

With generous assistance from the Government of Italy, we are now running a one-year course to train gene bank managers. The participants will be awarded the diploma of Associateship of IRRI in Genetic Conservation. Among the other important areas of conservation agriculture we are trying to foster, I would particularly like to refer to our intensified program in integrated pest management and integrated nutrient supply.

A. Integrated Nutrient Supply (INS)

Agronomy and Multiple Cropping Departments are intensifying their research and expanding it to cover the goal of developing a sustainable blend of the following sources of nutrients for irrigated and rainfed rice farming systems:

- *in situ* conservation of biomass in rice fields and control of grazing with the help of botanical pesticides such as neem cake,
- *Azolla* application,
- straw incorporation,
- cultivation and incorporation of green manures, and
- application of mineral fertilizers coupled with floodwater management.

Synergetic packages consisting of suitable blends of the above sources of nutrient supply are being tested under the INSFFER program, generously supported by the Government of Switzerland.

B. Integrated Pest Management (IPM)

There is need for greater interaction among scientists working on the following components of IPM strategy:

- genetic,
- biological,
- cultural,
- chemical,
- botanical pesticides, and
- socio-economic.

Varietal development and recommendations should be for a cropping system and not just for one crop. The varieties recommended should be tailored to the pest problems of each growing season.

Basic studies such as the ecology of weeds and weed problems related to moisture availability as well as more detailed work on disease epidemiology need to be intensified.

Concepts like insect thresholds need very careful field application or there could be problems of vector-borne diseases.

Above all, the social engineering aspects of transferring IPM and INS procedures to the field are being given greater attention. They will form important components of our program to assist rural women to participate in and derive economic benefit from new technologies.

V. COMMERCE

In the past, land use decisions were taken by farming families largely on the basis of the home needs of the family and of the immediate neighborhood. With modernization of agriculture, farmers produce food grains and other commodities not only for themselves but, more important, for the market. When this transition takes place, opportunities for producer-oriented and remunerative marketing become essential for sustaining and stimulating farmers' interest in modern technology.

In domestic trade, both cost and quality influence consumer demand. In international trade, in addition to competitive cost and desirable quality, stability of supply becomes extremely important. If appropriate technologies and remunerative marketing opportunities co-exist, a very rapid growth is observed in production gains. For example, the Punjab State of India produced 300,000 tons of rice in 1965-66. During 1984-85, the State harvested more than 5 million tons of rice, achieving an annual growth rate of 16% from 1965-66 to 1984-85. This was due to the availability of high yielding varieties coupled with the necessary support services and, above all, assured and remunerative marketing opportunities. Under commercial agriculture, the old distinction between food and cash crops vanishes and all crops become cash crops. This is where government policies in infrastructure development for improved postharvest technology, marketing, and transport as well as steps for ensuring fair returns to producers and reasonable prices to consumers become very important. Most developing nations have to simultaneously increase production by small farmers and consumption by the rural and urban poor. Hence attention to policy formulation becomes crucial to success.

The international trade environment is unfortunately very depressive for farmers. World prices have been moving downward across practically the entire range of agricultural commodities. The prospect of a general improvement in the situation does not seem bright. It is to sort out such international trade issues that the GATT Committee on Trade and Agriculture has been going into the problems of multilateral trade. Although this work was started more than 3 years ago, concrete conclusions are yet to emerge. Meanwhile, for many tropical products such as coffee, cocoa, and tea, the market is projected to expand by little more than 1% per annum up to 1990. The plight of the sugarcane farmers of Negros and other areas in the Philippines is well known to you.

An area of great concern in the postharvest handling of rice is grain drying. Many poor farmers have to dry the harvested paddy on paved roads. Inadequate drying can also lead to aflatoxin production resulting in liver ailments such as hepatitis. This is why two years ago we decided to intensify our work on grain drying with generous assistance from the International Development Research Centre (IDRC) of Canada. Those of you who have not visited the site of this project in our farm block F would profit by visiting the site and studying the different kinds of low-cost dryers under development. An important feature of these dryers is the effective use of renewable energy sources such as sunlight, wind, and biomass.

Leading rice exporting nations (Table 8) are today facing problems because of low international prices. Many importing countries require rice with specific quality characteristics. The decline in international prices in contrast to the increasing cost of production places developing countries in a very difficult situation because exports at competitive prices often can be done only with the help of subsidies (Fig. 12). Developing countries are also unable to assure their farmers a reasonable price in relation to prevailing international prices. On the other hand, developed countries such as Japan are in a position to offer high incentive prices (Table 9). Consequently, countries such as Thailand are planning to cut the area under rice crop, particularly in the dry season. During the wet season, rice continues to remain the crop of choice. Our farming systems network should be in a position to offer timely advice on the choice of substitute crops under such situations. Development of computer models on contingency crop planning under alternative weather and market situations should become an integral part of the research programs of the Asian Rice Farming Systems Network.

The unfavorable trade environment is forcing farmers to cut down on purchase of inputs such as mineral fertilizers (Table 10). Against this backdrop, what can IRRI do to revise its research priorities? I give below some of the

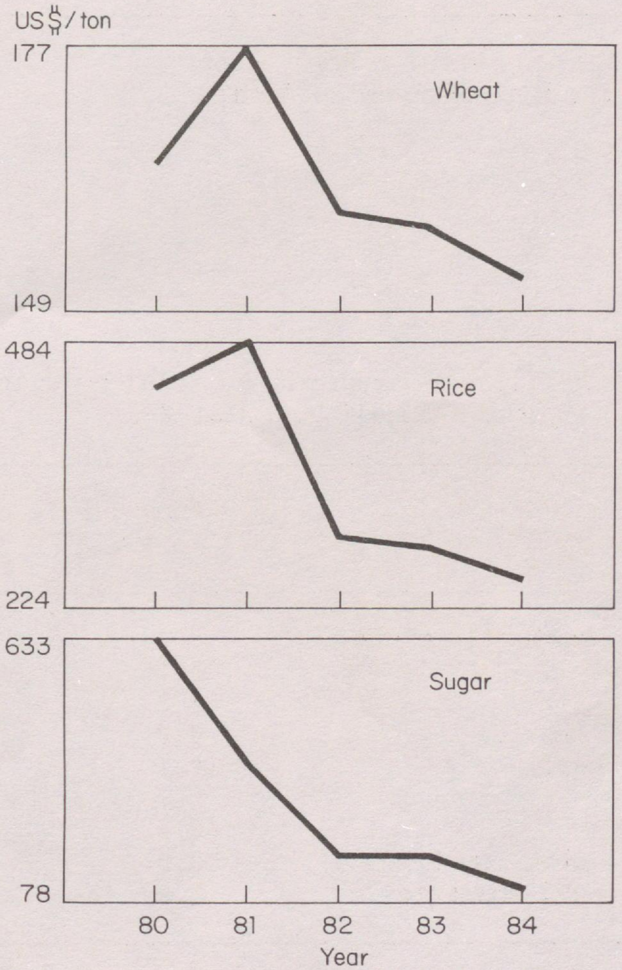
Table 8. Top ten exporters of milled rice
1982-84 (000+)

Exporters			
Thailand	3,959	Burma	526
United States	2,355	Australia	416
Pakistan	1,040	India	344
China*	1,033	Japan	251
Italy	538	Korea DPR	201
		Total World: 12,085	

Based on 1982-84 trade

*Including Taiwan, China

Source: FAO Trade Yearbook (Rome, annual)



12. International prices of wheat, rice, and sugar, 1980-1984.

Table 9. Farm-level price of rice as percentage of world price

Country	1961-65	1971-75	1976-80
Japan	203	246	391
South Korea	119	111	187
Indonesia		66	98
Bangladesh	127	163	93
Philippines	120	85	77
India	146	98	76
Burma	56	44	37

Source: Barker, Herdt & Rose, 1985. The Rice Economy of Asia.

Table 10. Fertilizer consumption, total nutrients, by region. 1971-80 and 1980-83.

	Annual rate of change 1971 to 1980	1980 to 1983
Developing market economies	............%.............	
Africa	6.1	-
Far East	10.2	6.5
Latin America	9.9	-7.8
Near East	11.1	10.4
Asian CPE	12.4	6.0
Developing countries	10.9	3.9
Developed countries	3.6	1.3

Source: FAO

areas of our research program which in my view need added attention:

- Reduction of production cost without yield reduction.
- Tailoring grain quality to match differential trade needs.
- Promoting stability through:
  - a. minimizing risks of pest epidemics,
  - b. risk distribution agronomy to suit different weather probabilities based on computer simulation models, and
  - c. promotion of sound public policies.

VI. CONSUMPTION

In this field again we face two contrasting challenges. On the one hand, the rural and urban poor suffer from undernutrition and malnutrition due to inadequate purchasing power. On the other hand, the food habits of the more affluent sector of the population are fast changing.

As I mentioned earlier, more than 300 million tons of grain reserves and more than 300 million hungry people co-exist on our planet. In India the Government has more than 30 million tons of grain reserve and at the same time millions of persons suffer from undernutrition. As early as 1861 Col. Baird Smith remarked that "Indian famines are not famines of food but of work. Where there is work, there is money and where there is money, there is food." If a famine of food was the major obsession in the immediate past, a famine of jobs will be the central preoccupation of the immediate future. Fortunately, a drop in the consumer price of rice helps poor families. There is evidence to suggest such benefits to poor families during the last 10 years as a result of higher rice production and productivity.

How can we help in adding a dimension of employment and income generation to productivity increases in rice farming systems? The following areas of research are relevant in this context:

- Income and nutrition orientation to farming and cropping systems research.
- Grain drying and storage, food processing, and marketing.
- Whole plant utilization.
- Management aspects of decentralized production supported by key centralized services.

The joint IRRI-UPLB project on <u>Prosperity Through Rice</u> aims to demonstrate methods of:

- producing more rice at low cost,
- optimizing the returns from the available sources of land, water, labor, and credit, and
- preparing value-added products from every part of the rice plant.

Figure 13 gives an idea of some of the opportunities available now for the use of straw, bran, and hull for preparing value added products. Components of the biomass utilization technology such as mushroom culture have immense potential for decentralized production supported by a few key centralized services (the supply of spawn and compost, and marketing).

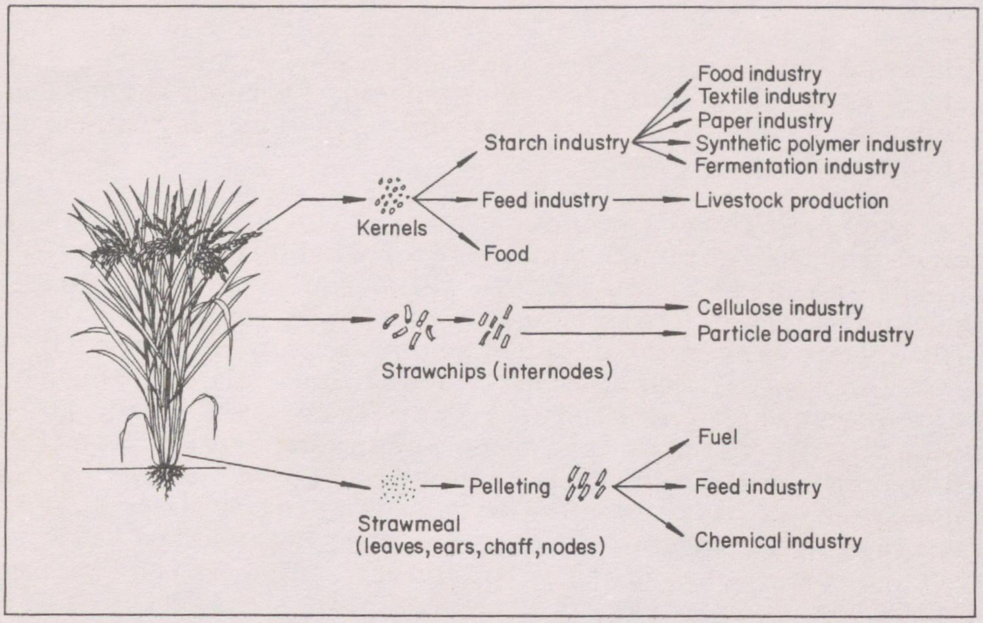
It is obvious that the farm sector alone cannot absorb all the surplus landless labor in the rural areas. We have to give a new orientation to the concept of land reform and widen this concept to include all forms of asset reform. For example, one of the greatest assets in rural areas could be the intelligent and effective use of emerging technologies such as biotechnology and microelectronics. Unless steps are taken immediately to train rural women and men, particularly those belonging to landless labor families, in new technologies, the poor will again be bypassed by the new technological opportunities. In fact, rural development should be defined as the conversion of all unskilled persons into skilled ones. It is only in this way that productivity can be increased and the quality of life improved. This is the major thrust of the training programs being organized under the UPLB-IRRI-ADB Prosperity Through Rice project. IRRI did pioneering research on constraints analysis in relation to <u>yield gap</u> in the 60s and 70s. We need to play a similar catalytic role in developing methods of constraints analysis in relation to <u>income gap</u> (Fig. 14).

Regarding the foods of the future, which will be increasingly the foods of choice among the rich, it is important to develop techniques and varieties suitable for the use of rice in various processed forms. The following are some of the opportunities available:

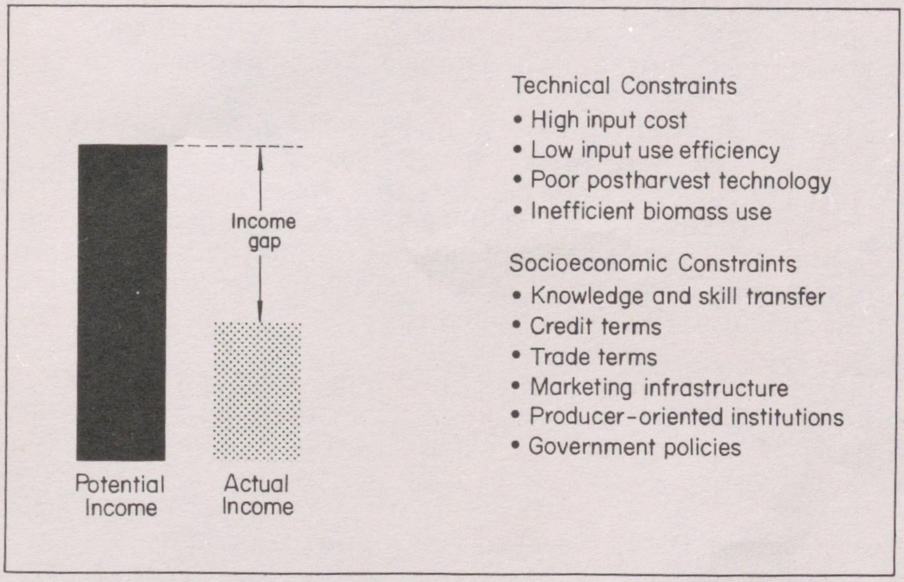
- Precooked and quick cooking rice, including infant foods.
- Convenience rice foods such as canned rice and ready-to-eat baby foods.
- Rice products such as puffed and popped rices, dry breakfast cereals and snack foods, and extrusion-cooked products.
- Rice dishes, puddings, breads, cakes, and crackers.
- Rice flour and starch.
- Rice noodles (extruded round and sheeted flat).
- Fermented rice foods including <u>idli</u> and <u>dosai</u> prepared in India.
- Rice wines and beer adjunct.

Our Cereal Quality Laboratory is working cooperatively with appropriate institutions in these areas.

We should proceed concurrently to 1) give a cost saving and income generating orientation to new rice technologies and 2) organizing collaborative research in rice processing and in catering to different consumer preferences. This twin approach will be necessary to stimulate and sustain both rice production and consumption.



13. Potential utilization of rice by-products leading to increased income and employment potential in agriculture.



14. Conceptual model for the study of constraints responsible for income gap (assuming absence of yield gap).

To achieve these aims, we need to review our ongoing farming systems research (FSR) methodologies from the following four angles:

First, the marketing aspects of the recommended multiple cropping sequences and mixed farming practices do not receive the same attention as the agronomic and production aspects.

Secondly, the technologies which can lead to a reduction in the cost of production without reducing yields and which can help to improve farm incomes need for their success under small farm conditions, a blend of individual initiative, government support, and group action in areas like soil and water management, plant and animal health care and post-harvest technology. Therefore, we need to shift our emphasis in farming systems research from an individual farm holding based on-farm research to a group of small holdings using a watershed in the case of rainfed areas or an irrigation command area in the case of irrigated agriculture or a village for purposes such as the promotion of integrated pest management procedures, as the unit for on-farm research. On-farm research based on the dynamics of group action will have to be integrated with current methods of on-farm testing in individual small holdings.

Thirdly, we need to integrate in on-going FSR explicit consideration to the impact of new technologies on women and to the development and testing of technologies for women-specific occupations. The poorer the household, the greater is the importance of independent access to income for women, so that the total household income is improved.

Finally, nutritional considerations should play an important part in the design of improved farming systems. Several nutritional problems can be overcome through a suitable restructuring of the farming systems and hence, a study of human nutrition linkages should receive priority attention in areas where malnutrition as well as specific nutritional disorders are endemic.

The present IRRI FSR methodology in Figure 15 is comprehensive. What is needed is that in the design of experimental farming systems, we should keep the following in view:

- remunerative marketing opportunities,
- reducing the cost of production through group endeavor in certain areas of production and post-harvest technology,
- generating additional opportunities for income and employment for women, and
- human nutrition linkages.

Measurement of "income gap" rather than "yield gap" should be a major goal in the testing phase of new experimental farming systems.

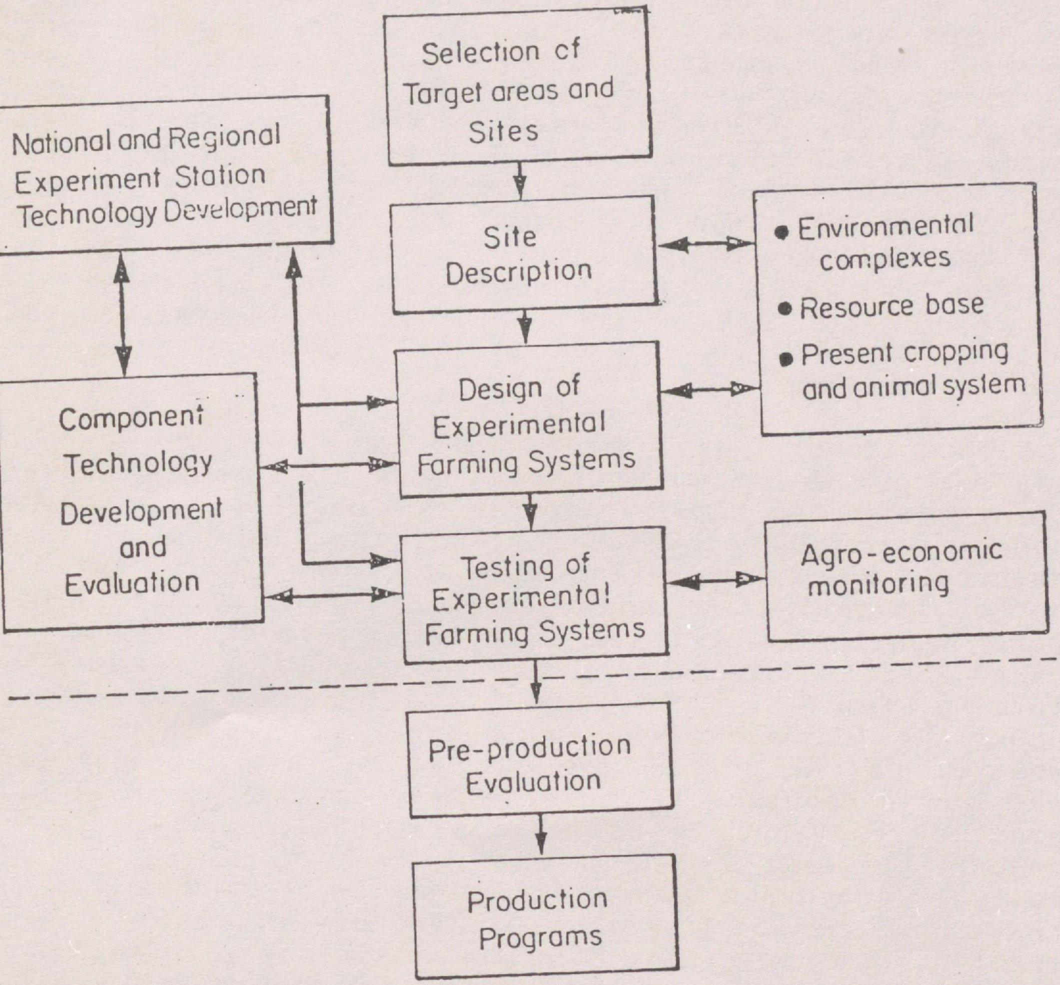


Fig. 15. Farming System Research and Development

VI. CONCLUSION

The Technical Advisory Committee (TAC) to the CGIAR has prepared an excellent and thought-provoking document on priorities for the CGIAR supported network of international centers. While TAC has recommended an overall reduction in investment on rice research, particularly in Africa, several priority areas that require additional investment have also been indicated. Some of the important shifts recommended by TAC, which have a bearing on IRRI's own research thrusts, are given in Table 11. As will be seen from the priority list in Table 11, our added emphasis on strengthening research on plant genetic resources conservation and soil health care, integrated pest management, and integrated nutrient supply are in the direction recommended by TAC. Our recent collaborative work in demonstrating the value of biomass utilization is also an area accorded high priority by TAC. We should further strengthen research linkages in the fields of human nutrition and in policy research. In policy research, we will have to develop the capacity for adding marketing considerations in our farming systems program. Thus, there are many new challenges and this is what makes life in a research institution so very exciting and interesting.

Our donors have been very generous and I wish to express our deep sense of gratitude to them. We have been informed by the CGIAR Secretariat that 96% of the minimum budget recommended by TAC for IRRI for 1986 has so far been assured. We are operating at a near zero growth rate in our budget in real terms and this makes priority determinations very important. I have indicated a broad research agenda based on the imperatives of the real life needs of rice farming families. Obviously, we cannot and should not undertake all such research ourselves. We should do only what we can do best. However, as an international center, we should continue to serve as catalysts in imparting greater relevance to national, regional, and international research priorities and strategies. Fortunately, our donors actively encourage and assist us in developing collaborative research programs with universities and research institutions in their countries. They are introducing several innovative methods of assisting IARCs in the discharge of their respective research mandates. An outstanding recent example of such help is USAID's program on Collaborative Research on Special Constraints Affecting the Programs of the International Agricultural Research Centers (IARCs). This was introduced in 1985. If we take full advantage of such opportunities for collaborative research, we can be of maximum assistance to our partners in national research systems. That is why we chose the theme "History of IRRI: the Power of Cooperation" as the motto for our 25th Anniversary symposia.

Table 11. Priorities for international agricultural research (Technical Advisory Committee to CGIAR-85)

Research area	Allocation in percent	
	Present	Proposed
Resource management and conservation research	7	13
Human nutrition linkages	1	2
Commodity conversion and utilization	1	2
Food and agriculture policy research	2	3