

SARP Research Proceedings

The SARP-project Phase III (1992-1995) Overview, Goals, Plans

Proceedings of the
'SARP Research Planning Workshop'
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H.F.M. ten Berge, M.J. Kropff & M.C.S. Wopereis (editors)

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DLO-Centre for Agrobiological Research, Wageningen
Department of Theoretical Production Ecology, Wageningen
International Rice Research Institute, Los Baños

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Preface

This document consists of two parts. Chapters 1-3 of Part 1 present an overview of the SARP project, its goals, approach, and organization. Chapter 2 gives a detailed description of activities and emphases during the current project phase, SARP-III: collaborative research, continued technology transfer, and the transfer of network coordination responsibilities. The administrative and scientific structures required to achieve the project goals are shortly described at the end of Chapter 2. Chapter 3 summarizes the expected outputs for the national centres, IRRI, and the 'Wageningen group'.

At the outset of the third phase of the SARP project, a Research Planning Workshop was held in March 1992 at IRRI, Los Banos, The Philippines. The purpose of this meeting was to finalize and present a planning of activities in the SARP research network, for the period 1992-1995. All simulation teams from the national research centres participating in the project presented their plans. The main conclusions of this workshop are listed in Chapter 4 of Part 1. The workplans of the individual simulation teams are compiled in Part 2 of this document. At the time of the workshop, these plans were updates of earlier documents.

The appendices provide more details: an overview of the various disciplines' representation in earlier training courses; research topics grouped by theme; the recommendations of a review committee; and some background information about rice production and consumption in Asia.

This issue appears only now, long after the Research Planning Workshop, because the SARP Research Proceedings series was launched only recently. Although the contents of this document have already been compiled in an earlier report, we are of the opinion that this overview issue should be included in the series, as a complement to the more thematic reports published in this series. It should be noted that this document reflects the state of the project in 1992 and has not been updated to include recent developments.

The Editors

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Part 1: SARP-III Project Overview

1. SARP from training to collaborative research

1.1 Introduction

1.1.1 SARP phases I and II

The third phase of the SARP project, described in this outline, follows two earlier phases. The first of these started in 1984 and was executed until October 1, 1987. The second phase started October 1, 1987, for a duration of four years, ending October 1, 1991.

The project had a twofold purpose in both phases I and II:

- to build research capacity in crop simulation modelling at national research centers (NARCs) in Asia and at IRRI;
- to improve rice based cropping systems through collaborative systems research by the NARCs, IRRI and AB-DLO/TPE.

Training

In building research capacity, SARP's training program featured four particular aspects:

1. NARCs participated with multidisciplinary teams, not with individuals, and team supervisors were involved.
2. Participants were initiated by a long training program.
3. Support was given to these teams after the training program.
4. All tools, including a PC-AT computer, were donated to each team.

The training program has been executed three times: in 1986/87, 1988/89, and 1990/91. It consisted of three components:

- A basic training module in simulation and systems analysis. This module (6-8 weeks) included the handling of PC's and simulation languages, hands-on learning to use simulation modules, and the formulation of case studies.
- A case study conducted by each team at the home institute. Case study issues were selected by the participants in accordance with ongoing research at their home institutes. Teams conducted their case studies during eight months and often combined their simulation studies with experimental work. SARP staff visited each of the teams for about one week.
- A workshop (2 weeks) where teams presented the results of the case studies and discussed new research proposals. The outputs of the three training workshops (1987, 1989, 1991) have been reported in proceedings.

Fifteen teams composed of participants from 19 NARCs in nine countries have followed the training. The countries and participants with their respective disciplines are

listed in Appendix 1. Two groups have been established without a formal training. With the exception of 2 teams, all are actively pursuing systems research, using crop models.

Training materials have been developed and are available to all participating NARCs and to others in the form of books, software and slide-tape instruction modules. They provide a basis for future basic courses to be given by NARCs at the national level. Two of such national courses have been organized; one by a Chinese team, and one under the umbrella of the Indian Council for Agricultural Research.

Collaborative research

Topics for collaborative research were proposed by the teams on the basis of their relevance for local conditions in each of the mandate regions of the national institutes. These studies started usually as case studies during the training program.

A selection of topics for continued SARP support was made in consultation with the teams. Criteria were:

- topics should have relevance for more than one or two teams;
- simulation and systems analysis can play an important role in improving research output.

Research topics are listed in Appendix 2. A distinction can be made between applied research, and process research related to crop level production processes. Most of the NARCs have strong interests at both research levels.

Four research themes (Section 2.3.1) have been established as a framework for coordination of research activities. In the last two years, workshops have been organized around these themes, to promote interaction among scientists from different NARCs.

1.1.2 Project review

In September 1990, a DGIS review team evaluated SARP to assess results obtained, addressing advantages and disadvantages of the SARP approach with respect to specific items. Its conclusions and recommendations for a third phase are cited in Appendix 3.

The evaluation report recommended continuation of the SARP activities, where SARP-III should concentrate on:

- consolidation of the simulation modelling capacity at the NARCs initiated in the earlier phases of the project; no further expansion of the network;
- gaining increased support from IRRI and encouraging the use of simulation modelling in IRRI research programs;
- actively demonstrating the usefulness of crop simulation models to NARCs;
- further development of models in collaboration with IRRI scientists involved in collaborative research projects, addressing high-priority factors affecting productivity of crops in rainfed environments.

1.1.3 Perspective

SARP started with instruction to teams and collaborative research. A long term commitment has been envisaged from the start and was made explicit in a joint AB-DLO-TPE-IRRI 'memorandum of agreement' on long term collaboration towards improvement of research capacity at the national institutes. The third phase of the project is required to achieve a sustainable adoption of systems research techniques by the participating NARCs.

Further training - largely through collaborative applied research - remains an important component of the project.

SARP's relevance for the further development of national research and extension systems beyond the current participants is exemplified by the local training courses organized by the NARCs already participating in SARP (China; India; Indonesia, in preparation). Research managers increasingly become involved in planning of SARP activities, and in output evaluation. To maximize the impact on national systems, other mechanisms should be identified and elaborated during the third phase of the project. Consultations and feedback with specialists and with institutions that have a mandate in this field, such as ISNAR, will be helpful.

The transfer of collaborative research coordination from SARP staff to NARCs and IRRI is a major challenge in this phase of the project, as no antecedent experience is available to determine how to achieve this effectively.

1.2 SARP-III objectives

1.2.1 Long term objectives

The ultimate objective of the project is to achieve a more productive and sustainable agriculture by improving agricultural research, extension and planning, in particular in developing countries with rice-based cropping systems.

An important step towards this goal is the improvement of research efficiency at NARCs. Output of agricultural research can be much increased by using the techniques of systems research to identify research priorities. In addition, the costs of experimental work can be much reduced with the help of systems analysis methods. New research problems such as those connected with environmental issues and sustainability, can be tackled effectively by these quantitative methods. Increasing research efficiency by consolidation of the capacity to use these techniques is therefore a second long term objective.

1.2.2 Short term objectives

In view of the long term objectives, the recommendations of the review team, and the above observations, the third phase of the project has the following immediate objectives:

1. To consolidate in existing simulation teams at NARCs a critical mass of competent staff using the modelling approach as a research tool; the output of those teams will be in the form of publications, 4-year research plans, and other NARCs outputs; applications in each of the themes will be demonstrated.
2. To consolidate IRRI as a center for modelling expertise in rice-based cropping systems (thereby encouraging adoption of systems research at other NARCs through IRRI's contacts and networks), and to integrate SARP's research activities with those in IRRI's research consortia; to support IRRI in incorporating systems research courses in its training program for NARCs. These are necessary steps to prepare the transfer of SARP coordination activities to NARCs and IRRI.
3. To conduct collaborative systems research on selected topics, thereby reinforcing the skills of participants in using the systems approach, and accelerating progress towards tangible results; this involves the maintenance of a network for coordinated research among NARCs, IRRI and the 'Wageningen group'; and in some cases the use of new techniques to integrate results from different sources.
4. To support trained teams at NARCs in training additional scientists in systems research, thus ensuring sufficient numbers of adequately trained staff in national research organizations; SARP will not undertake to initiate new teams or members by international basic training programs. Key modules of training materials will be made available to serve as 'building blocks' of curricula being developed by the participating universities.
5. To transfer coordination activities to a number of NARCs (theme research and local training) and to IRRI (research and international training).

Each of the participating institutions (for acronyms, see Appendix 5, and Section 2.1) has its own particular priorities with respect to these immediate objectives:

NARCs	: objectives 1,3,4,5
IRRI	: objectives 2,3
AB-DLO/WAU	: objective 3

Objective 3 may need additional explanation. Conducting research, both at crop process levels and in applications, plays an important role in consolidating the acquired simulation and systems analysis expertise, specifically in the existing teams, and at the NARCs as a whole. This is so for two reasons:

- Researchers learn the new techniques thoroughly by applying them to actual, local problems; to support this learning process it is necessary that NARCs and SARP staff continue to work in close collaboration, interpreting experimental and modelling results, reinterpreting observations, designing new experiments, and adapting models.
- It needs to be shown to research managers that the systems approach can lead to practical results which can not be obtained to the same extent, and with the same efficiency, by traditional research methods.

While the above implies the necessity of close interaction between the NARCs and 'Wageningen'/IRRI, a network structure encouraging collaboration among NARCs is im-

perative - in addition to 'bilateral' interaction - to identify fields of common interest and to achieve a joint planning of research activities, thus making effective use of the scientific support offered by the project.

1.3 SARP's relevance for rural development

Rural development depends on changes in many aspects. Major improvements can be introduced by changing the economic conditions, i.e. prices of farm outputs or of material and labour inputs. But although changing the economic scene is an important way to stimulate rural development, it is certainly not the only way.

Improvement of the efficiency of inputs, leading to reduced production costs per unit output, can also induce or stimulate rural development. Such improvements in input efficiency have been achieved in different parts of the world by breeding better crop varieties, distributing healthier seed, improving fertilizer application methods, more effective crop protection, and the training of farmers. Indonesia's rice production increased dramatically at the end of the 1970's in response to a program focused on input efficiency, combined with credit facilities and guaranteed prices.

The problems of increasing input efficiencies are different for the various ecological environments. While in Africa generally the average level of production per unit area is to be increased, most Asian countries face high yield variability as a major problem in their poorer regions.

The high yield variability found in rainfed rice systems (just over 50% of the world's rice acreage) is often associated with low efficiencies of inputs, resulting in low economic returns. Land degradation due to overexploitation is a threat typically linked with low input farming. Improvement of production systems subject to highly variable physical and biological stresses is particularly difficult because stresses of various nature interact, and because risk evasion defines farmer's goals different from just increasing average yields.

The high input systems at the other end of the scale pose their own characteristic problems: environmental pollution, and long term instability (pest build-up; soil degradation; diseases; micro nutrient balances; salinization). Excessive use of external inputs in order to increase productivity leads to reduced efficiencies, and its side-effects jeopardize sustainability. Typical examples are cotton production in the Sudan, and rice in parts of Indonesia, China and Korea. To prevent such developments, appropriate technologies should be introduced along with external inputs.

Both in low and high input systems, improvement of input efficiencies should be based on sound understanding of the production systems. This requires proper research methods, tailored to the specific questions locally raised. Systems research helps to assess the options for improving efficiency over the full range of environmental and input domains, and to identify alternative production systems. SARP contributes to the development and implementation of the systems approach in agricultural research.

2. SARP-III project description

2.1 Participating organizations

SARP-III is a collaborative project of the following institutions:

Dutch Institutions:

- DLO-Research Institute for Agrobiological Sciences (AB-DLO)
- Department of Theoretical Production Ecology (TPE-WAU) Wageningen Agricultural University

International Institution:

- International Rice Research Institute (IRRI)

National Agricultural Research Centres (NARCs):

BRI	Bangladesh Rice Research Institute (Bangladesh)
CES	Crop Experimental Station (South Korea)
CNRI	China National Rice Research Institute (China)
CRIFC-BORIF	Central Research Institute for Food Crops, Bogor Research Institute for Food Crops (Indonesia)
CRIFC-SURIF	Central Research Institute for Food Crops, Sukamandi Research Institute for Food Crops (Indonesia)
CRRI	Central Rice Research Institute (India)
GPUAT	Pantnagar University of Agriculture and Technology (India)
IARI-WTC	Indian Agricultural Research Institute, Water Technology Centre (India)
KKU	Khon Kaen University (Thailand)
MARDI	Malaysian Agricultural Research and Development Institute (Malaysia)
TNAU-TNRRI	Tamil Nadu Agricultural University-Tamil Nadu Rice Research Institute (India)
TNAU-WTC	Tamil Nadu Agricultural University- Water Technology Center (India)
UPM	Universiti Pertanian Malaysia (Malaysia)
UPLB	University of the Philippines in Los Banos (Philippines)
ZAU	Zhejiang Agricultural University (China)

Donor organization:

Directorate General for International Cooperation (DGIS), Ministry of Foreign Affairs, Netherlands.

2.2 SARP methodology

SARP's methodology towards achieving the project's two ultimate objectives is based on the following characteristics:

- intertwining of training and research directed to problems selected by NARCs;
- multidisciplinary interaction among scientists at the NARCs;
- collaborative research of NARCs, IRRI and the 'Wageningen group' on themes common to most of the participating NARCs;
- analysis of the processes that determine crop production;
- application of process knowledge in an integrated form to help formulate research conclusions for all themes.

Joint research is indispensable in transferring the skills of modelling and systems analysis. In this third phase of the project again, the development of human resources will go hand in hand with systems research in which national scientists, IRRI staff and SARP staff join to work towards practical results.

Specialized tools in the form of software are used for systems analysis, systems optimization, and data analysis and management. A considerable fraction of project activities has been directed, therefore, to the development of software materials and the subsequent training of research staff. Models are open at any level to the user. This is a requirement to achieve a true adoption of the new techniques. Adaptation of existing models to specific needs associated with investigating local problems will be a continuing activity. In this respect, SARP's approach contrasts with that of other modelling groups.

The network structure developed in the earlier project phases aims at improving research output of individual teams by:

- identifying common research priorities;
- encouraging joint planning and execution of research in these areas of common interest;
- exchanging research outputs and methodologies.

2.3 Project activities

2.3.1 Research activities

Each of the countries and regions for which the participating national institutes do research is characterized by its own specific conditions and demands in terms of production targets, rural development goals, and current social, economic and agrotechnical constraints. A brief overview of demographic conditions, current and future food demands, and actual rice production levels is given in Appendix 4. The conditions with respect to food grain production differ widely among the participating countries. The entire spectrum from rainfed, low input systems to fully controlled irrigated systems with high inputs and outputs is covered. This wide diversity is obviously reflected in the research priorities and the activities of researchers at the NARCs.

The SARP review team stated explicitly in its recommendations that social or economic objectives or constraints should not be included in the models at crop production level. Nevertheless, socio-economic conditions are taken into account by the NARCs themselves when selecting the relevant problems. Crop and cropping systems models supply valuable information for feasibility studies of management and development options in various agro-ecosystems, and as such are used as tools in a wider context. The interactive techniques available now to optimize different goals simultaneously under given constraints provide an objective basis to evaluate social and economic consequences of explicit choices made at the farm or regional levels.

Supporting, in a single project, the work of a large number of researchers - currently a total of 80 scientists - working under such varied conditions on problems of local relevance, requires first of all identification of common interests. In addition, it implies that what SARP should offer to the NARCs must be of a general character. Systems research on selected topics can satisfy these requirements.

Systems research involves the two seemingly contradictory aspects of analysis and integration. In the analysis phase, research is directed towards improved understanding of basic processes. Integration aims at understanding the behaviour of the system as a whole in a quantitative manner. Both are required in applied research, e.g. in systems optimization towards different possible goals, in evaluation of varieties, in scanning development options, etc. This is true for applied research at all levels of aggregation, i.e. an individual crop, the cropping system, the farm, or the region.

Activities in the research program of SARP-III explicitly cover both of the above aspects: process research at the field level, and applied research at the levels of single crops, cropping systems, farming systems (selected cases), and production on regional and national scales.

Process research

Although the relative importance of different production factors varies from place to place at all scales (field, farm, region, country, and beyond), only a limited number of basic processes operate to determine crop yields in all rice based production systems. The processes studied in the SARP-III collaborative research program are related to important constraints to crop production. The classification of these constraints provides the framework of 'themes' in which SARP's research is organized:

1. 'Agro-ecosystems'; constraints at the cropping systems level: timing (planting, duration), cultural practices, and cropping patterns (crop type, rotations); (the theme was previously called 'cropping systems').
2. 'Potential Production'; constraints related to radiation, temperature, and crop varietal characteristics that determine the crop's performance in a given physical environment; these are the 'growth determining' factors.
3. 'Crop and soil management'; constraints related to water availability, soil fertility, and the crop's exploration of soil; these are also indicated as 'growth limiting' factors; (the theme was previously called 'water, nutrients, roots').

4. 'Crop Protection'; constraints related to infestations by pests and diseases and competition by weeds, and the crop's response to damage by these 'growth reducing' factors. The particular topics addressed within these broad fields are listed in Appendix 2. Research activities in each of the above themes will be guided by a theme leader and a theme coordinator. For their tasks, and the transfer of responsibilities to IRRI and to the NARCs, see Sections 2.4.3 and 2.3.3.

Applied research

The systems approach yields a quantitative and general understanding of the basic processes involved in crop behaviour and yield formation. This is in contrast to traditional and empirical on-site research, often based on 'trial-and-error' and allows application of process knowledge in a wider range of production situations than possible with other methods. Systems research therefore enables a more efficient use of research funds available in the developing countries.

Applied research activities in the third phase of the project have been planned on the basis of those priorities that most of the participating NARCs have in common:

1. Optimization of cropping patterns to make better use of available resources to achieve a more productive and sustainable agriculture. This includes the possible introduction of new crops and green manures; improved utilization of water resources; elements other than crops to supplement farm income (e.g. fish, livestock).

At a few NARCs there is a demand for the use of optimization techniques at the cropping systems level; such techniques allow interaction with scientists from other disciplines including farm economy, agro-ecology and rural sociology. An example is provided by the ongoing research at the Water Technology Center of Tamil Nadu Agricultural University on optimization of production and farmers' equity in large tank irrigation systems in Southern India.

The implications of climate change for cropping systems is another important aspect studied by a number of NARCs with the help of the systems approach (Appendix 2).

2. Optimization of farm inputs tailored to local, specified conditions; this includes increasing the efficiency of fertilizers, water, biocides, and labour, both from economic and environmental viewpoints.

In most production situations, either highly intensified with full water control or low-input, high-risk rainfed systems, minimization of inputs per unit output continues to be one of the major research goals. While in the low-input systems - e.g. east India, see Appendix 4 - this minimization is prompted by economic reasons, environmental aspects are becoming increasingly important in highly intensified systems (South India, China, Korea and Indonesia). In Indonesia, the reduction in fertilizer subsidies has again increased the interest at the farm level in the economy of input use.

3. Supporting the breeding and selection of new varieties (of rice and other crops in rice based cropping systems) better adapted to various biological and physical stresses. Several of the NARCs have extensive pre-release testing programs for newly developed varieties. Much empirical work is repeated in different parts of the NARCs' man-

date areas, consuming research funds that can be saved by applying a more systematic approach. One aspect is the reduction of experimental sites for varietal screening, based on the selection of characteristic sites with the help of simulation models, as has been done at CIAT. Models can also have an important role in the design of ideotypes for different environments and are being used in this fashion by TNAU-TNRRI and CNRRI.

4. A major activity of almost all participating NARCs is to add a spatial dimension to each of the above three issues. This implies, in its basic form, the zonation of growth conditions (climate, soils, pests and diseases). Successively, production potentials of these environments are to be determined, at different levels of elimination of limiting conditions (water, nutrients, pests, weeds). Thus, key elements for studies on land use alternatives are assessed.

The difficulties and costs involved in current empirical practice make simulation models a powerful alternative, that enable a refined assessment of yield variability in time and space. Some of the teams (KKU; IRRI) are ready to start using geographic information systems (GIS) in their zonation activities. In several other institutes (Central Research Institute for Food Crops, Indonesia; Water Technology Center, New Delhi, India) there is a strong demand for efficient tools to perform nationwide inventories of production potentials.

5. Developing dynamic and conditional thresholds for pests and diseases in integrated pest and disease management systems.

These thresholds are to be based on a quantitative analysis of the nature and level of damage due to pests and diseases in various crop growth circumstances. Thresholds are used in supervised and integrated pest and disease management systems such as those developed by FAO for rice; and the program for winter wheat in the Netherlands, which led to significant reductions in the use of biocides due to increased awareness by farmers about pest and disease impacts. Within SARP, teams at UPM, KKU, and SURIF are working along these lines.

2.3.2 Activities in continued technology transfer

Consolidation of the established systems research skills at the NARCs requires application of the introduced techniques in applied research. This serves a twofold purpose: (1) the participating scientists improve their skills in applying quantitative methods towards practical goals; and (2) this generates the outputs necessary to convince research management beyond currently involved NARCs that the systems approach can much enhance the research efficiency.

As a consequence, the emphasis in technology transfer shifts from basic training courses towards workshops on specific research themes (listed in Section 2.3.1). The workshops will be centered around 'collaborative research issues', i.e. topics of direct interest to several of the NARCs, to IRRI and to the participating Dutch institutes. By com-

binning process research and applied research in a given field, the workshops simultaneously aim at improving the understanding of production processes and at demonstrating how simulation and systems analysis can be used to achieve research goals. The basis for progress through these frequent workshops is an intensive interaction between all scientists involved (IRRI, NARCs, 'Wageningen') during the entire phase of the project. The workshops will be organized annually, for each of the research themes; increasingly, modellers from other groups will be involved.

One of the project's goals is to ensure that training facilities be established although SARP will not initiate basic courses during its third phase. In the course of time there will be a growing demand for basic training in systems research. IRRI will take over these training activities. SARP-III will assist in incorporating elements of its international training program at IRRI's training center.

SARP will support the NARCs in giving local (national) training courses, mainly by developing case studies and providing lectures on special issues. The project will assist, upon request, in developing a framework for curricula in systems research at the universities participating in SARP.

Basic materials for training in modelling crop production will be distributed in the form of computer aided instruction sets, slide-tape modules and books. In particular, manuals for simulation of crop growth under nitrogen stress and in the presence of pests or diseases will be developed. Self-instructive refresher courses will be developed and made available for those team members and other scientists who have a fragmentary knowledge of simulation techniques.

Each year a meeting for all team leaders will be organized. This meeting will be merged with the annual 'Agro-ecosystems' workshop mentioned earlier, because the role of the team leader - as that of agro-ecosystem research - is to encourage integration of the activities of individual, discipline-oriented team members.

The exchange of scientists will be actively encouraged. A total of 38 fellowships is available for short (3) and longer (12 months) exchanges among NARCs, and between NARCs and 'Wageningen' or IRRI. Development of research capacity at NARCs requires scientists with a PhD level. The project offers a few PhD fellowships to young team members. These 'sandwich' fellowships combine a research period at the home institute with an initial and final stay of six months at Wageningen to prepare and finalize a thesis.

SARP staff will continue to visit all participating teams once per year for direct interaction with the researchers, and in order to maintain contacts with research leaders in the respective institutes.

2.3.3 Activities to ensure continuation beyond SARP-III

At the end of SARP-III, teams at NARCs are expected to have gained sufficient experience with systems analysis techniques to independently apply these in addressing their institute's priority fields. Yet, a sustained network after SARP-III will enhance progress.

Therefore, a major and explicit aim of the project is to reach the stage where thematic research in a network is coordinated by the NARCs, supported by IRRI. One condition to achieve this is the gradual and full integration of SARP activities in existing research structures at NARCs and at IRRI.

As far as the NARCs are concerned, the current research structure could be maintained if the responsibility of coordination activities within each theme is adopted by a number of NARCs. To prepare such a transfer of responsibilities, coordination of research activities during SARP-III involves two scientists for each theme: a researcher who continues to be based at IRRI/Wageningen (years 1-2), and a counterpart in one of the NARCs (years 2-4). Effective arrangements with the home institutes of these counterparts have to be designed, as coordination should become the responsibility of institutes rather than individuals.

A long term continuation of network activities will also require the continued involvement of IRRI. IRRI, having a mandate to conduct research and assist in developing human resources in national rice research systems, anticipates by incorporating basic modelling courses in its training program. Since the current SARP teams at the NARCs, however, can be the principal nuclei for in-country dissemination of simulation skills, IRRI's main role in training will be to support dissemination through monitoring, consulting, and later evaluation of the local training courses. IRRI can, through its infrastructure, play an important role in ensuring the relevance and quality of in-country training programs. Key modules of training materials will be made available to serve as 'building blocks' of curricula being developed by the participating universities.

Aside from supporting training programs, IRRI will work at embedding simulation modelling activities, currently under SARP, in its research consortia. These are ecosystem-oriented, and have been named 'Upland', 'Rainfed Lowland' and 'Irrigated', in accordance with IRRI's new research structure. Key-sites for these joint activities are on Sumatra (Upland), in East India (Rainfed Lowland) and in the Philippines (Irrigated). In the long run, a restructuring of SARP research according to the above rice ecology classification may evolve.

At the end of SARP-III, research coordination should be entirely transferred to the NARCs and to IRRI. The 'Wageningen group' aims at continued involvement in the network after this phase, but in the role of participant.

The transfer of coordination and leadership in systems research to NARCs is a major challenge. Therefore, a small expert group will be convened halfway this third phase, to review progress and steer the most effective course.

2.4 Institutional framework

2.4.1 Locations

The project will be executed by all national centres listed in Section 2.1. Coordination activities, and research on special topics will take place at IRRI and in Wageningen.

2.4.2 Administrative structure (organizing institutes)

Day to day coordination of the project will be the joint responsibility of one project leader at IRRI, and one project leader at AB-DLO.

AB-DLO and TPE-WAU are responsible for contacts in the Netherlands, including with the donor, DGIS. AB-DLO has final responsibility as the principal contractor. Two theme coordinators will be stationed in Wageningen. IRRI coordinates the network activities and will be the home base for two of the theme coordinators.

2.4.3 Organization at NARCs

The project's scientific capacity consists of approximately 80 participating *scientists* in 15 teams at national institutes in Asia (see list in Section 2.1). Each team is headed by a *team leader* who coordinates team research and serves as a contact person.

Collaboration with teams at the NARCs will continue to be based on joint workplans. *Team supervisors* are senior research managers at the NARCs, who are involved in the planning of team activities. They are frequently invited to workshops, and interact with SARP staff during team visits. The team supervisors aim at incorporating team work plans in the workplans of their institute, and in agreements on collaboration with IRRI. Other research managers are reached by direct personal interaction, and by symposia such as the International Symposium on Systems Approaches for Agricultural Development in December 1991, co-organized by SARP. Four of the NARCs will take over the responsibilities of the *theme coordinators*.

2.4.4 Scientific structure

The scientific development and coordination of the project is the responsibility of *theme leaders* and *theme coordinators*. Annual meetings involving all theme leaders and coordinators and team supervisors will ensure a consistent development across themes. In addition, a newsletter serves to promote the exchange of ideas and development within the network.

Theme leaders are senior staff at AB-DLO/TPE and IRRI. They provide direct scientific backstopping to the theme coordinators, and will remain active during the entire project period. They are institutes' own contribution to SARP.

During the first three years of the project, two theme coordinators will be stationed at AB-DLO/TPE, and two at IRRI. Their activities include convening of annual workshops, preparing research plans on common topics - both experimental and modelling aspects - and encouraging exchanges of scientists among institutes, and on-site collaboration. They have also a supporting research task.

During the second half of the project, coordination of theme research will shift to NARC-scientists (Section 2.3.3). For India, this process has already started: all SARP activities are routed through an overall India coordinator.

2.4.5 Workplan

The project will extend over a period of four years, starting January 1, 1992, and ending December 31, 1995. Thematic workshops will be organized annually. Research plans were discussed during the March 1992 planning workshop at IRRI (see Chapter 4) and formulated by the NARCs during the following 2-3 months (see Part 2).

Teams will be visited annually by SARP staff (theme coordinators and theme leaders). The timing of visits depends on progress in ongoing research, and on the time schedules of individual researchers at the NARCs, IRRI and 'Wageningen'.

3. Expected output SARP-III

3.1 National centres

Independent teams, experienced in systems research, will be established at the participating national research centers. They will apply crop modelling as a tool in research, extension and planning. (Short term objectives, 1)

Some of the centres will gain experience in organizing training courses at the national level, and the universities among the participating NARCs will incorporate systems research in their curricula. (Short term objectives, 4).

The role of coordinating research in each of the four research themes will be transferred from AB/TPE to a few of the national centres, and to IRRI. (Short term objectives, 5).

Research output will consist of local applications of systems research, among others in the form of:

- regional maps of production potentials - for various crops and varieties - under successive elimination of limiting factors; land use options at the regional level;
- recommendations on farm inputs such as biocides and fertilizers; crop management; economic threshold levels for the main pests and diseases; development alternatives at the farm level;
- improved screening techniques for newly developed crop varieties (key properties);
- identified characteristic trial sites for field screening of varieties;
- ideotypes designed for given environments (physical and biological);
- assessments of impacts on rice of global climate change.

3.2 IRRI

IRRI will integrate the systems approach in its research and training program, allowing a central role of the institute in further dissemination of the techniques in the rice producing countries. Research activities at the NARCs, currently conducted in a collaborative SARP context, will become part of IRRI's off-station research structure, embodied in the research consortia centered around 'rice ecologies' (Upland, Rainfed Lowland, and Irrigated). (Short term objectives, 2, 5)

3.3 Institutes in the Netherlands

Collaborative research contributes experimental results, scientific insights and simulation programs on selected problems. Some of these are relevant for European production conditions too, such as those regarding nitrogen cycling and fertilizer efficiency.

Standardized models and modules for crop simulation, and corresponding user-friendly interfaces will be an important output as well.

3.4 Network

While the teams should be able to apply crop modelling as a tool in research, extension and planning, their research output can be much enhanced by a network for continued interaction among NARCs, and between IRRI, NARCs, and 'Wageningen'. Coordination of theme-oriented network activities will therefore be transferred to a few NARCs and to IRRI. (Short term objectives, 5).

4. Conclusions of the SARP-III planning workshop

The main conclusions of the SARP-III Planning Workshop which was held at IRRI in March 1992 are summarized below. Almost all team leaders and team supervisors attended the meeting.

4.1 Agro-ecosystems

In SARP-III the Agro-ecosystems theme coordinator will investigate the possibilities to acquire a simple data base/mapping software package.

An important issue in this theme will be agro-ecological zonation. A simple approach will be used. For extrapolation to regional level two options have been distinguished:

- a. from data directly to mapping
- b. from data via simulation modelling to mapping.

When extrapolating, important issues will be:

- Data Quality/Availability
- Model Quality.

Most teams will work on applied research. Clear outputs of applied research (such as yield variability maps, recommendations for cropping systems) were identified.

4.2 Potential Production

Teams were interested to work both on applied and process oriented research. Applied research topics included the effects of climate change on rice growth in Asia, plant type design for increased yield potential in relation to environmental and N-management, genetic characterization and genotype x environment interactions. Output products were identified per activity. IRRI will develop a manual for model parameterization and evaluation and use of potential production models to solve problems in rice ecosystems.

Most process oriented research topics are linked with the theme Crop and Soil Management, because of the need to include measurement of plant-nitrogen. Topics included studies on respiration, tillering, and phenological development as a function of photoperiod and temperature. Outputs will include well tested modules.

Model parameterization and uncertainty analyses will result in well evaluated models for potential production and a database of genetic coefficients.

4.3 Crop and Soil Management

Focus in this theme will be on process oriented research during the first two years. Process oriented research for this theme was split up in two parts: research for N management and research for water management.

Experimental and modelling activities in process research for N management will deal with:

1. N uptake capacity (total root mass, shoot growth rate etc.).
2. Root studies:
 - root formation rate;
 - root senescence rate;
 - root activity;
 - root geometry.
3. Allocation on N to organs.
4. Effect of N on sink formation.
5. Soil N dynamics (availability).
6. Leaf photosynthesis and senescence.

Experimental and modelling activities in process research for water management will focus on the following topics:

1. Definition of water stress.
2. Effect of water stress on sink formation.
3. Drainage to manipulate tillering.

Output products will include management recommendations for N and water for specific local cases. It was concluded that the progress in process research will benefit much from continued common experimentation, as initiated in SARP-II. One relevant component in such common trials that should get more attention is site characterization.

4.4 Crop protection

Several pathosystems were selected for research within the SARP network. For insects SARP related research activities will be restricted to stemborer. For diseases this will be blast, bacterial leaf blight and sheath blight.

Process oriented research will focus on quantification of damage mechanisms and on validation of experiments at field level under irrigated conditions. These experiments will be conducted by all teams involved in research on a specific pathosystem.

Applied Research will explore management possibilities. The model validated through process research is applied to different management options such as:

- cultivars differing in resistance/tolerance;
- nitrogen fertilizer rates;
- planting density;
- rainfed growing conditions.

This part of applied research requires further validation and involves renewed comparison of model results with field experiments.

Contributions to the field of plant breeding and IPM were discussed. Possibilities for decreasing damage changing aspects of plants habitus, e.g. consequences of increased plant height, tillering capacity and crop development rate need to be explored. Other issues may include development of criteria for chemical control of pests and establishment of critical periods or threshold levels for chemical control.

It was suggested to organize both mini-workshops per pathosystem (insects/diseases) and mini-workshops in which all theme researchers can present their recent simulation and experimentation results.

Part 2: SARP-III crop simulation research plans, 1992 - 1995

Edited by M.C.S. Wopereis

5. Workplan of the Bangladesh Rice Research Institute

Bangladesh Rice Research Institute
Joydebpur 1701
Gazipur
Bangladesh

The BRRI-SARP Simulation Team is composed of¹ :

Mr. Sk.Md.A. Sattar	Agronomist (Team leader)
Dr. A.J.M. Azizul Islam	Team supervisor
Dr. Md.M. Aminul Haque	Pathologist
Dr. Musherraf Hussein	Plant Breeder
Dr. A. Motaleb Bhuiyan	Agronomist
Mr. A. Rashid	Agronomist
Dr. A.N.M. Rezaul Karim	Entomologist
Mr. M. Alam	Agronomist
Mr. M.U. Ghani	Plant Breeder
Dr. L. Rahmen	Plant Pathologist
Mr. Motahar Hossain	Physiologist
Mr. N.K. Sharma	Plant Pathologist
Mrs. N. Jhoardar	Irrigation Engineer
Mr. M.K. Mondal	Irrigation Engineer
Mr. S. Islam	Agrometeorologist/Physiologist
Mr. K. Bashir	Plant Breeder
Mr. B. Ch. Roy	Agronomist
Mr. N. Islam	Agronomist

¹ At the time of the Planning Workshop, March 1992.

Background

Rice is the major crop in Bangladesh covering nearly 80% of the agricultural land with the major pattern being rainfed double rice cropping. However, the average productivity of rice per hectare is low due to many reasons e.g., inadequate supply of water and nutrients, use of low yielding varieties and severe outbreak of pests and diseases. Moreover, recurrent natural hazards like drought and flood often limit rice production.

In Bangladesh, winter (dry season) is the most favourable season for crop production, however, at present covers only 20% of the irrigated rice (boro rice). Attempts have been made to improve rice as well as other crop production through the use of multiple cropping technology, high yielding varieties, rational use of fertilizers and irrigation and improving pest and disease management strategies.

However, the cultivation of high yielding varieties of rice often demands high inputs particularly irrigation, fertilizer and pesticide. This warrants introduction of short duration and low input rice and non-rice varieties in the existing rice based production system. Wheat, a less water requiring crop, seems to be emerging as a potential replacement for the winter-irrigated (boro) rice. Multiple cropping with wheat or pulses may also remove the malnutrition problem of the country to a large extent.

Development of a sustainable rice based crop production package thus appears to be a great challenge in the agricultural research of Bangladesh. Much research efforts are required to identify and resolve the constraints and finally establish the alternative package of crop production technology. Simulation research appears to be a promising way to achieve the above goal with minimum time and energy, since simulation may reduce the amount of field experimental work.

The present research plan is comprised of four different research components:

1. potential production;
2. cropping systems;
3. water and nutrients;
4. insects, diseases and weeds.

Objectives

- Development of a suitable, sustainable rice based crop production package under different agro-ecological zones in Bangladesh.
- Optimization of resources (crop, soil, water, nutrients etc.), productivity and profitability.
- Determination of long term stability of potential productivity of new patterns in relation to long term variability in weather, soil nutrients, pest and diseases as a function of alternative management options.
- Extrapolation/zonation of research findings in potential agro-ecological areas of the country.

Table 1. Work plan For 1992-1995 (whole team)

Activities	1992	1993	1994	1995
Weather data			
Field experiment			
Model adaptation			
Model validation			
Model application			
Compilation and reporting			

5.1 Agro-ecosystems

5.1.1 Optimization of cropping systems by simulation in various eco-systems

(Alam, Sattar, Bhuiyan, Matahar, Nazrul, Bilash and Bose)

Background

The general background of the research plan above has explained the rationale for undertaking the present simulation research in which cropping system is an important component. Appropriate rice based cropping patterns are expected to increase total yield, improve food nutrition situation and meet the changing socio-economic demands of the country. However, empirical experimentations to help resolve the problems are very costly with respect to time, labour and money. Simulation may largely reduce the costly experimentation.

Objectives

1. To analyze the productivity of cropping patterns under varying levels of moisture and soil nutrients.
2. To study the stability of cropping patterns in relation to long term variability of weather, soil and moisture.
3. To delineate and map potential areas for alternative cropping patterns.

Approaches

Cropping patterns and moisture regimes

1. Rice - Wheat systems under rainfed and irrigated conditions.
2. Rice - Rice system under rainfed conditions.
3. Rice/Cowpea - Rice - Cowpea/Wheat systems under rainfed conditions.
4. Performance of Cowpea as pre- and post- rice crop in the Rice - Rice cropping pattern.

Crop data

Most crop data for rice and wheat are available. Small experiments need to be conducted to obtain certain variety-specific crop data. All data on cowpea have to be obtained from experimentation and literature.

Simulation modelling

1. AMAN.CSM, a model for simulating productivity of photoperiod sensitive rices, developed by Sattar and Bilash and LIQ or LID of Penning De Vries et al. will be used for wheat. For cowpea, a model developed by IRRI/SARP will be used.
2. Simulation results will be used to delineate the extrapolation areas for the cropping patterns using the agro-ecological zonation from FAO/UNDP. This zonation has been done based on thermal zone, moisture (flooding) zone, and land form (soil physiographic units, soil texture, and land type). The smallest administrative unit considered is the so-called Upazila. Still, much variation in soil characteristics that determine crop performance exist within such a unit. Therefore, zonation can be improved by using location specific information on soil characteristics such as texture, moisture, drainage and soil nutrient availability.
3. The potential area for crops or cropping patterns will be delineated using GIS, software and hardware however is not available at BRRI. A simple GIS (data base/mapping system) package may be soon available through the SARP project. The local CIDA office can provide GIS training.

Work plan

1. Rice-Rice-Wheat cropping under rainfed and irrigated conditions.
 - a. Crop growth data for rice - Sattar and Bilash
 - b. Crop growth data for wheat - Alam and Sattar
 - c. Crop growth data for Cowpea - Alam
 - d. Simulation run & reporting - Sattar and Alam
2. Rice/Cowpea-Rice-Cowpea/Wheat pattern under rainfed conditions.
 - a. Crop data - Motahar/Bhuiyan
 - b. Simulation run & reporting - Ghani/Nazrul/Bhuiyan

3. Modelling performance of Cowpea grown before rice (Cowpea-Rice-Wheat pattern)
 - a. Crop data collection - Alam
 - b. Simulation and reporting - Alam/Sattar
4. Database handling and mapping - Bose

N.U. Ahmed will provide necessary guidance to Alam and Bhuiyan to identify problems related to cropping systems.

5.1.2 Generating weather data to simulate crop production

(Bose)

Objectives

1. To determine minimum amount of weather data needed to get a valid estimate of future weather data.
2. Crop forecasting on the basis of generated weather data.

Approaches

Ten years of historical weather data are available for some locations. The available model to generate weather data will be used to generate weather data for the 9th and the 10th year using the first 8 years. The crop growth simulation model that has been developed, tested and adapted will be used to simulate crop productivity for the 9th and 10th year. The results will be compared with the observed data of 9th and 10th year. If simulation gives satisfactory results then this technique will be applied to forecast crop performance for the next 5 years.

5.2 Potential production

5.2.1 Transplanting shock effects on growth of rice seedlings of varying age

(Sattar and Bilash)

Background

This study began last year. The model AMAN.CSM, which is based on L1Q and TIL modules of Penning De Vries et al. is being refined. The transplanting shock may be responsible for slow growth after transplanting and variation in tillering rate. This has been introduced in the model as a sudden set back in DS and in all integrals. The crop data of

Nizersail and BR22 collected from experiments done in the 1989 - 1992 aman seasons will be used.

Objectives

1. To study the time lag between transplanting and regeneration of growth of rice seedling.
2. To study the climatic and seedling age effects on the length of transplanting shock in rice.

Approaches

Initiation : Aman 1992
Termination : Aus 1993
Location : BRRJ Joydebpur
Treatments :

- A. Seedling age (days): 30, 45, 60 and 75
B. Variety : Aus - BR14
 Aman - BR22 and N.sail
 Boro - BR3 and BR14
 Plot size : 4 × 2 m
 Spacing : 25 × 20 cm with one seedling per hill
 Fertilizer : 100-18-33 kg/ha of N-P-K. N will be applied in three splits with the first one 15 days after planting; others at basal.

Data collection

- A. Seedling data at uprooting
1. Shoot and root length
 2. No. of leaves per plant
 3. Dry weight of shoot and root
 4. N, P, K, S, Zn contents
- B. Main field data
1. Pre establishment record (at alternate day upto 20 DAT beginning 2 DAT).
Sample size is 15
 - i. Conc. of N, P, K, S, Zn in plant
 - ii. Dry shoot weight
 - iii. Date of new leaf and tiller initiation

5.2.2 Potential production of some advanced Aman lines in different locations

(Ghani, Mannan and Jatish)

Background

Breeders have developed advanced photoperiod sensitive rice lines promising for growth under rainfed conditions. Screening of these lines in field experiments at different locations requires a lot of time, manpower and money. Simulation models can be very helpful for primary screening of lines thus reducing the number and size of field experiments needed.

Objectives

To evaluate the productivity of breeding lines promising for growth in the transplanted aman season.

Approaches

The promising lines will be grown at Joydebpur to have variety specific information needed as input for the AMAN.CSM model of Sattar and Bilash. The model will be validated using those crop data under Joydebpur conditions. Subsequent simulation runs will be done for different agro-ecological zones for which weather data are available.

Field trial

Promising lines : BR850, BR1725, BR1870,
BR22 and IR64
Row spacing : 25 × 20 cm
Fertilizer : 100-18-33 kg/ha of NPK
Weed control : Herbicide fb hand weeding
Seedlings/hill : One
Seedling age : 30 days

Data collection

1. Date of sowing, transplanting, panicle initiation, heading and maturity.
2. Leaf area and dry weight of leaf, stem and root at 0, 15, 40, 65 and 90 DAT.
3. Yield components and yield of grain and straw.

Workplan

1. Field trial & data collection - Mannan/Ghani
2. Data analysis and simulation - Jatish/Ghani

Field trial : June - December 1992
Analysis and parameterization : January - March 1993
Model validation & testing : April - May 1993
Simulation run for Joydebpur : June - August 1993
Simulation run for other locations : Rest of 1993

5.3 Crop and soil management

5.3.1 Modelling the nitrogen cycle in transplanted rice (Jatish and Sattar)

Approaches

This program will be subdivided into 4 subprograms. Investigations into each of the subprograms will be done during a period of one year. Most data will be collected from literature search and some are available from different investigations in the home institute and other NARCs. The model L3C developed by SARP/IRRI will be used for subproject 4 after necessary modifications, while for others no model is available as yet but has to be developed in consultation with the SARP/IRRI group in due time.

Workplan

The subprograms and period of study are:

1. N input to organic and inorganic pools 1992
2. Decomposition and transformation of N 1993
3. Nitrogen losses from flooded rice systems 1994
4. N uptake by crop 1995

Data collection, parameterization, development, testing and validation of model will be done subprogram wise and the final model will be available at the end of 1995.

5.3.2 Optimal irrigation requirement and water resources utilization for rice based cropping

(Manoranjan and Nafis)

Background

In rainfed environments the major cropping pattern in Bangladesh is rice - rice - fallow. The first rice (aus) is grown during April to July and the second one (aman) is grown from August to December. The total production of this pattern usually does not exceed 5 tons/ha because of the use of mostly local cultivars due to lack of irrigation facilities.

The maximum rainfall is received during June to September. This indicates that a non-rice crop, particularly pulse, can be fitted into the pattern using residual soil moisture after the harvest of aman rice, provided the first rice crop is established early (mid-March) with irrigation. The total production of this alternative pattern might greatly exceed the present practice as an additional crop would be grown and modern cultivars of rice might be used.

In a gravity irrigation system it was observed that farmers applied water when it became available without paying much attention to rain water utilization. For effective utilization of available water resources the existing irrigation practice should be modified. To economize irrigation water used for the alternative cropping practice proper utilization of rain water must be emphasized.

Information is available on the performance of crops under irrigated and rainfed conditions. Little is known about the soil moisture status after the harvest of the aman rice for different soil types, which is necessary for non-rice crop establishment.

Objectives

1. To assess the amount of water resources available for crop production in selected locations.
2. To develop suitable cropping patterns with minimum water use.

Approaches

Location : Gazipur and Khulna
Cropping pattern : Rice - Rice - Pulses/Vegetable

Data collection:

1. Rainfall.
2. Groundwater level.
3. Evaporation.

4. Irrigation (amount and frequency).
5. Soil moisture in every 15 cm depth upto 1 m.
6. Soil physical properties.
7. Yield and Yield contributing characters.

Simulation

The submodules L1D, L2C and L2SU will be used to estimate productivity of the cropping patterns.

Workplan

Duration: 1992 to 1995

1. Field investigation - Manoranjan
2. Data analysis & simulation - Nafis

5.4 Crop protection

5.4.1 Effect of Ufra disease on yield of BR11 and BR22

(Haque, Karim and Rahmen)

Background

Ufra disease of rice is becoming more and more important in Bangladesh. Previously it was a problem confined to the deepwater rice areas only. Nowadays, it has been found to be a recurring problem in the Aus, T. Aman and Boro rice crops also. After the two devastating floods of 1987 and 1988, the disease appeared in areas where it had never been occurred before.

Now, it is important to increase the awareness about the disease among the farmers, extension agents and the administrators. Modelling may help in standardization of yield loss against quickly measurable parameters of the disease severity and in development of disease control strategies.

In 1990, an experiment on the effect of both sheath rot and ufra diseases on the yield of BR11 and BR22 was conducted at BRRI, Joydebpur. It was experienced that if the experiment is planned for one of the diseases at a time, it might be better studied. In 1991 an experiment on ufra disease was conducted. During the experimental period weekly samples of rice hills from inoculated and uninoculated plots were collected starting from 15 day after inoculation, oven dried and carbohydrate contents in the samples were estimated

using the coefficient given by Penning de Vries et al., (1989). Data are being analyzed and inputted into the model.

Objectives

1. To simulated potential yield of BR11 and BR22 and to compare the results with observed yield data under Joydebpur weather conditions.
2. To simulate yield loss caused by ufra disease at different levels of the disease. Simulated outcome will be compared with observed data to evaluate the efficiency of L1Q + TIL model in simulating the yield loss.
3. To develop the relationship of FPNE to NFFL.
4. To find the relationship between loss in carbohydrate content and ultimate yield due to the disease.

Approaches

An experiment will be conducted at the BRRRI Farm, Joydebpur, Bangladesh. Two rice varieties, BR11 and BR22 will be included in the test. The two varieties will be grown at DATEB 190-200 under potential production level conditions. Twelve plots of 10 m² (4 × 2.5) each will be laid out, separated by 1m levies between blocks (3 replications) and between plots (2 vars × 2 treatment: inoculated and uninoculated).

Inoculation will be carried out using 10,000 nematodes/plot. Care will be taken that the nematodes are freely suspended in standing water. They should not be attached to the original host tissues nor should they be aggregated together. The plots will be well separated from each other with high levies preventing water flow from plot to plot. The number of nematodes in water and plant samples from the plots will be determined periodically (i.e. monthly or fortnightly). At harvest time, 200-400 randomly selected tillers from each plot will be examined for percentage of panicle emergence. Empty and filled grains of some of the randomly selected panicles out of the above mentioned samples will be counted. These two parameters, FNDTI and FPNE will be included in the Model L1Q + TIL to estimate NFFL and ultimate grain yield. Crop and weather data available at BRRRI will be used. Simulated and observed yields will be compared.

Expected output

- Development of a realistic relationship between FPNE and NFFL.
- Simulated values for grain yield will correspond with observed values.

Table 1. Workplan 1992

Workplan	J	F	M	A	M	J	J	A	S	O	N	D
Setting up field expt.						***						
Inoculation						*	**					
Monitoring												
Nema. Popin.								**	**	**		
Data coll. & harvest											*	**
Simulation run	***											
Report writing		***										

Further Research

1. Based on next year's results future research strategies will be planned aiming at reducing losses due to ufra disease.
2. Improvement of the model by analyzing the relationship of the effects on individual parameter e.g. FPNE to FNFFL.
3. Study the effect of sheath rot disease on yield of BR11 and BR22.

6. Workplan of the China National Rice Research Institute

China National Rice Research Institute
171 Tiyuchang Road
Hangzhou 310006
Zhejiang Province
P.R. of China

The CNRRI-SARP Simulation Team is composed of:¹

Mr. Zhu Defeng	Physiologist (Team leader)
Prof. Min Shaokai	(Team supervisor)
Mr. Cheng Shihua	Plant Breeder
Mr. Zhang Xiufu	Agronomy Department
Mr. Pan Jun	Soil Scientist
Mr. Chen Zhongxiao	Plant Protectionist
Ma Jufa	Plant Protectionist
Mr. Xichun Chen	Statistician
Mr. Xu Li	Agronomist

¹ At the time of Planning Workshop, March 1992.

6.1 Potential production

6.1.1 Modelling the impact of climate change on rice cropping systems in China

Background

Climate change will be an important factor affecting rice production during the decades. Through the improvement of characteristics of rice varieties and the modification of rice cropping systems, the negative effects of climate change may be reduced in some regions and the positive effects explored.

It is estimated that due to climatic differences between 1990 and 2020 the CO₂ concentration in the atmosphere will increase more than 100 ppm and that the temperature will rise by 1.5°C. The increase in temperature will reduce the rice growth duration and prolong the season for rice growth. Through the shift of single rice system to double rice systems, and double to triple, and the choice of the type of rice varieties, the effect of climate change may be explored and mitigated.

Objectives

- To qualify potential production of rice in future weather.
- To quantify the effects of climate change over the next three decades on the growth duration of the various types of rice varieties and on the season for rice cultivation.
- To determine the adjustment needed in rice cropping systems and the type of rice varieties in the different regions.

Approaches

- Future climate scenarios will be estimated by GCM for main rice cropping regions.
- The phenological LID development model will be used to predict the rice growth duration for current and future weather conditions.
- The season for rice growth will be calculated based on safety dates of sowing and maturing.

Workplan

1992-1993

1. Future climate scenarios.
2. Simulating effects of climate change on rice growth.

1994-1995

1. Mapping potential production under future weather conditions.
2. Adjustment and recommendation of rice cropping systems and choice of the type of rice varieties.
3. Mapping rice cropping systems in the different rice cropping regions under future weather conditions.

Expected output

The effect of future climate change on growth season and growth duration will be shown in current rice cropping systems. Improved rice cropping systems will be recommended to rice scientists, especially breeders and policy makers.

6.1.2 Designing new high yielding irrigated rice varieties

Background

Rice is the staple crop in China. The planting area is 33 million ha which stands for one third of the total planting area of food crops. Rice production occupies 44% of the total food production. Release of new varieties and relevant cultural technology play a key role in raising the potential production of rice varieties. Breeding and release of dwarf varieties increased potential production levels on a large scale. Dwarf varieties improve the harvest index and have a better lodging resistance and higher tillering ability. From the 1970's onwards it is emphasized that the release of high yielding varieties should be combined with disease and insect resistance in rice breeding. This will result in rice yields that are higher and more stable.

The increase of potential production levels for rice varieties progresses only slowly. It appears that the yield level of existing varieties has reached a peak. To increase further potential production of rice, some breeders have proposed several breeding strategies:

- For the varieties with long growth duration, maintaining dry matter production and increasing harvest index.
- For the varieties with short growth duration, maintain harvest index and increase dry matter production.

As far as yield components are concerned, grain number per area and grain weight per area should be increased.

The question is which characteristics must be improved to increase grain production and harvest index, and increase grain number per area and grain weight per area. The present research focuses on designing a plant type of high yielding rice suitable to specific environments. Methods to evaluate genotype x environment interrelations in specific agro-ecological environments will be explored.

Objectives

- Propose main characteristics of rice plant which will give higher yield in various environments.
- Design a new plant type for a high yielding rice variety in irrigated rice cropping systems
- Evaluate the application of simulation technology in crop improvement and genotype x environment interrelations.

Objectives

1. To determine the effects of leaf angle and canopy leaf distribution on canopy photosynthesis at different growth stages. Find out optimum leaf angle, the pattern of canopy leaf distribution, plant height and the pattern in different environments.
2. To determine the effects of light canopy distribution on leaf nitrogen redistribution.
3. To determine the effects of the pattern and redistribution of canopy leaf nitrogen on dry matter production and grain filling. Investigate the effect of leaf nitrogen contents and its redistribution in different heights of the canopy on biomass production and transportation, and of nitrogen uptake in the ripening stage on leaf nitrogen maintenance and biomass production.
4. To determine the effects of tiller formation, growth and death on partitioning pattern of biomass.
5. To determine the relationship between specific leaf weight (SLW) and the development of leaf area and canopy photosynthesis. Study the direct and indirect effects of SLW on the development of leaf area and canopy photosynthesis.
6. To determine the relations of leaf area per plant and characteristics of leaf photosynthesis to large panicle.
7. To design and test plant types of high yielding rice varieties using simulation models.

Approaches

1. Analyze the characteristics of high yielding rice varieties from biomass production, accumulation, partitioning and morphological characteristics.
2. Combining analysis of existing data, experiments and modelling.
3. Evaluate the effects of morphological and physiological characteristics of rice on growth and yield by simulation.

Workplan

1992

1. Collect and analyze existing data on characteristics of higher yielding varieties.
2. Propose detailed working plan and experiments.

1993

1. Modify existing model and simulate the growth and yield with some promising characteristics to evaluate their effects on yield.
2. Carry out necessary experiments to analyze the differences between old and modern varieties (high yielding) and analyze the effects of characteristics on growth and yield.

1994

1. Do necessary experiments.
2. Run the model to analyze plant type of high yield varieties.

1995

1. Reporting.
2. Demonstrate the value of simulation results in breeding and cultivation.

Expected output

Simulation models and methods will be proposed to design plant types for different agro-ecological environments. Characteristics needed for higher yielding varieties will be proposed from physiological and morphological sides. Plant type of rice suitable to specific environments will be proposed.

6.2 Crop and soil management

6.2.1 The availability and uptake of nitrogen for rice growth in different ecosystems

Objectives

The relationship between the availability and uptake of nitrogen is an important factor affecting rice growth. The availability of nitrogen is determined by the concentration of nutrients (ammonium) in soil solution and the root length density.

Because of variability in weather, soil type and because of varietal differences, the availability of nitrogen will vary in different rice ecosystems. An important goal of this study is to study N-uptake in different soil environments.

Workplan

1992

Collect data on nitrogen application, uptake, yield and soil conditions, and conduct experiments.

1993

Determine nitrogen in rice parts and soil nitrogen etc.

1994

Analyze the results and reporting.

Expected output

Find out the relationship between soil N availability and uptake of nitrogen in different soil environments.

6.3 Crop protection

6.3.1 Modelling the formation and death of rice tillers

Background

An important characteristic of small-grain cereals is their capacity to tiller. A vigorous crop of rice may produce over 20 shoots per plant. Only 3-10 shoots per plant survive to continue to yield. Scientists have suggested that in modern cropping systems this over-production of tillers may be unnecessary. Old and modern management practices have been compared in terms of morphology and yield. These studies indicated that the higher yields of modern rice management practices are associated with an increase in the proportion of tillers surviving to bear ears at harvest. Field experiments with rice have shown an increase in rice tiller ear weight when some tillers are removed. Recently new rice plant types have been proposed which have a higher proportion of tillers to bearing panicles as an important characteristic for high yield.

However, there is no way to predict the tillers formation and death of rice tiller in the field. The impact of the formation and death of tillers on grain number per plant and partitioning also needs to be studied.

Objectives

- To quantify the relation of tiller formation to environmental factors.
- To predict tiller formation and death under field conditions.
- To propose a practical method to control and stimulate tiller growth.

Activities

- To determine the processes of tiller formation and death and the relation between tiller growth and leaf nitrogen content and light in canopy.
- To relate tiller formation and death to phenological development stage, the growth of leaves and dry matter production.
- To modify the model to predict the formation of tillers.
- To evaluate and demonstrate the value of simulation to predict tiller formation under field conditions.

Workplan

1992

Determine relation of tiller formation and leaf nitrogen content and leaf growth.

1993

1. Determine relation of tiller formation and light in canopy.
2. Conduct experiments.

1994

1. Evaluate and modify the model on tiller formation.
2. Analyze the main factors which affect tiller formation.

1995

1. Demonstrate the value of simulation to predict tiller formation and analyze the effect of tiller formation on growth and yield.
2. Reporting.

Expected output

The main factors affecting tiller formation and the relationships among tiller growth, leaf growth and nitrogen content and light in canopy will be identified. A modified model to predict tiller formation will be proposed.

7. Workplan of the Zhejiang Agricultural University

Zhejiang Agricultural University
172 Kai Xun Lu Road
Hangzhou 310029
Zhejiang Province
P.R. of China

The ZAU-SARP Simulation Team is composed of:¹

Prof. Wang Zhaoqian	Agro-ecologist (Team supervisor)
Dr. Yang Jingping	Agro-ecologist (Team leader)
Mr. Lu Jun	Soil Scientist
Ms. Luo Weihong	Meteorologist
Mr. Pan Deyun	Agro-ecologist (On leave)
Mr. Xu Zhihong	Plant Protectionist
Dr. Yan Li Jiao	Agro-ecologist

¹ At the time of Planning Workshop, March 1992.

Background

There is a relative shortage of farmland in China due to the heavy population pressure and rising living standards. In Zhejiang province, the governor is calling for cereal productions of 15 tons per hectare per year (three crops). The rice production is focusing on intensive farming to increase the output. However, the temperature regime in Zhejiang province is unfavourable for double cropping, the nitrogen efficiency is still low; and there are serious pests and diseases problems in rice production. Therefore, it is very important to optimize the management of crop production, increase the application efficiency of nitrogen, and reduce the yield loss caused by pests and diseases.

Objectives

1. To optimize the cropping system.
2. To optimize the agronomic measures by using models.
3. To increase the efficiency of nitrogen application.
4. To improve the pest and disease forecasting.
5. To disseminate the dynamic models and simulation techniques to other provinces.

7.1 Agro-ecosystems

7.1.1 Simulation of wheat interplanted corn then rice triple-cropping system in paddy soil (Yang Jingping)

Background

Integrating grain production with animal husbandry is becoming common practice in Zhejiang province. In many rice production areas new cropping trends are emerging, and the wheat=corn-rice cropping pattern has been widely adopted (the = sign denotes interplanting). This cropping system has not only increased grain yield but also improved the soil physical conditions because of rotation of dryland and wetland crops. The main tasks of this project are to understand the physiological mechanisms of two crops (i.e. wheat and corn) when interplanted, to solve the competition problem, to increase the utilizing efficiency of solar energy, heat and water resources and to obtain high yields. The research may give decision information to farmers by means of computer simulation analyses of the wheat=corn-rice pattern.

Objectives

1. Dynamics of weed-corn intercropping will be simulated using CSMP language for a complete growing season and will be compared with field experimental data.
2. Detailed research on light, heat, water utilization of crops will be conducted in the field and will be simulated. The distribution proportion of carbohydrates in the inter-planting duration of two crops will be simulated and tested, to find out the relationship and function between each crop.
3. A field experiment on the effect of wheat interplanted corn on final yield of two crops and their potential yield will be conducted, and used to validate simulation results.
4. General software will be developed.

Workplan

1. Field experiment

Two cropping patterns, barley=corn-rice, wheat=corn-rice, will be established in the field using 3 different row spacings. Corn density is kept the same in all treatments, i.e. 75,000 plants per hectare. In order to study the climatic (light, heat) effects on corn growth, 4 sowing dates will be used with a 10 days interval. A greenhouse experiment will be conducted to investigate the competition between both crops for light, temperature, rainfall and nutrient factors.

2. Computer simulation work

Based on field and greenhouse data, the simulation model for two interplanted crops will be selected and adapted. The MACROS crop growth simulation model is the basic model to be used. After validation and improvement of the model, it will be used to describe the whole growth duration for the wheat=corn--rice cropping pattern. A research thesis and report will be written.

Time table

Jan. 1993 - Dec. 1995

Field experiment, data collection, model selection and working out program, translator and compiler.

Jan. 1996 - Aug. 1996

Testing, running and modifying the cropping pattern module.

Sept. 1996 - Dec. 1996

Improving the model, using the model to analyse and study the Wheat==corn--rice cropping system, Preparing the research thesis.

7.2 Potential production

7.2.1 Further validation of the dew formation model and its adaptation to rice blast forecasting and management

(Luo Weihong and Xu Zhihong)

Background

Dew is an important factor in fungi-dominated rice diseases, especially rice blast. The simulation of dew formation on the rice canopy forms the basis for simulating damage due to rice blast and may contribute to rice blast forecasting.

Dew formation simulation model

A simple dew formation simulation model has been developed. For its practical use, two problems have to be solved: Further validation of the model is needed using additional experimental data and a method has to be developed to estimate night cloudiness from standard weather data.

Rice blast forecasting and management aspect

Current rice blast forecasting and management are based on the existing statistic epidemic model in China, which does not allow for the development of quantified forecasting and adequate management of rice blast. In order to get a better knowledge of the mechanisms of outbreak and epidemics of rice blast and to control this rice disease efficiently and economically, it is necessary to use epidemic and damage mechanism simulation models.

Prospects of quantifying rice blast forecasting and management

The rice blast dynamic epidemic model and damage model make it possible to quantify forecasting and management of the disease. However, the rice blast dynamic epidemic model has not been practically used because the leaf wetness which is an input parameter in the model is not practically available. The development of a simpler dew formation simulation model is needed. Quantified rice blast forecasting and management will be obtained by integrating the dew model, the epidemic model, the damage model, and the basic crop growth model (L1D).

Objectives

This study aims at the following two goals:

1. Making the dew formation simulation model be practically used: i.e. incorporate the dew model into the rice blast epidemic model for forecasting and to enable weather stations to supply daily dew duration data.
2. Quantifying rice blast management by integrating the damage model and the basic crop growth model, and simplifying the integrated model into a set of tables for spray decision making. This integrated model will act as a blast warning system, and will supply a set of tables to plant protection stations and agricultural bureaus of provinces or cities, responsible for issuing pest warnings and pest management policies. The tables will function as a guideline to 'look up' the blast epidemic probability and the corresponding yield losses under given weather conditions.

Approaches

Experiments and data collection

1. Experiment for validation of the dew model
Observations of dew formation (amount and duration) and other relevant weather data will be done over night for about two weeks during the rice growth season. The observation nights will include different weather conditions i.e. clear, cloudy, and overcast sky. Blot paper will be used to observe the dew formation by weighing hourly.
2. Estimation of the night cloudiness
In Chinese weather stations, weather observations are taken three to four times a day. Observations are done at (02h), 08h, 14h, and 20h. Measurements include air and soil (0, 5, 10, 15, and 20cm depth) temperature (including maximum and minimum values), air humidity (including maximum and minimum values), sunshine hours, rainfall, evaporation, wind speed, cloudiness etc. In addition, the time course of air temperature and relative humidity is automatically recorded using a thermograph and a hydrograph. The possible way to estimate night cloudiness is to find a relationship between cloudiness and the other weather parameters (or their variation rates) by using statistical (regression) methods.
3. Experiment and data collection for rice blast
Rice blast has been studied for many years in China, and a lot of data on epidemic and yield loss is available. Experiments on effects of severeness of the disease on photosynthesis, yield loss, and specific characteristics of the rice plant, and effects of development stage on severeness, still have to be done.

Models needed in this study

1. The simple dew formation model - this study.
2. The rice blast epidemic model - through SARP.
3. The rice blast damage model - through SARP.
4. The basic crop growth model (LID) - already available.

Workplan

Program of activities:

1. Estimate night cloudiness based on standard weather data.
2. Validate the simple dew formation simulation model.
3. Collect weather data and rice blast data from literature and by doing experiments.
4. Adapt the rice blast epidemic model and the damage model.
5. Integrate the above four models and make a quantified model of rice blast forecasting and management.
6. Evaluate the integrated model by comparing the results of with the actual situation and improve the integrated model.
7. Write a paper.
8. Simplify the integrated model into a set of tables and explain the final results (tables) to plant protection stations and agricultural bureaus.

Time table

Time (year/month)	1992	1993	1994/ 1-7	1994/ 8-12	1995/ 1-7
Activities					
1	+	-	-	-	-
2	+	-	-	-	-
3	+	+	-	-	-
4 (if available)	+	+	+	-	-
5	-	+	+	+	-
6	-	-	+	+	+
7	-	-	-	+	+
8	-	-	-	+	+

Notice: '+' means 'yes' and '-' means 'no'.

7.2.2 Simulation of growth and population quality of high-yielding hybrid rice and prediction of potential yield under future possible climatic conditions in south China

(Zheng Zhiming)

Background

A high-yielding rice population must have adequate individual plants and a high population quality. Population quality can be expressed by several indicators, such as weight of sheath, effective leaf area, amount of spikelet, grain/leaf (the ratio of number of grains to effective leaf area), spikelet-root vitality (the ratio of product of root weight and root vitality to number of spikelets).

Global climate change will undoubtedly influence rice production. Especially the instability and risk of late hybrid rice in South China will increase. Therefore, it is very important for decision-making and rice research to predict potential rice yield for possible future climatic conditions.

Late hybrid rice is the main target to increase rice yield in South China. Its cultivation has a certain risk because the yield is affected by climatic factors such as temperature. Research has been focused mainly on breeding techniques and the physiological basis of formation of hybrid vigor. Very few work is done on the growth and population quality in high-yielding hybrid rice and its yield potential under future climatic conditions.

Objectives

- To investigate growth and development of late hybrid rice.
- To establish quantitative indicators for high-yielding population quality.
- To optimize cultivation measures.
- To predict potential yield under future possible climatic conditions.

Approaches

- A. Simulation of the growth and high-yielding population quality of late hybrid rice
 - collect data from literature and adapt the model;
 - conduct experiment;
 - simulate and carry out analyses;
 - validate the model with field experiments;
 - modify the model and demonstrate the simulation results.
- B. Prediction of potential yield under future possible climatic conditions of late hybrid rice in South China
 - collect data on climate and production of late hybrid rice;
 - adapt and modify the model;
 - simulation modelling.

Expected output

- Simulation model of growth and high-yielding population quality of late hybrid rice.
- Quantitative indicators for high-yielding population quality.
- Optimal cultivation measures.
- Model prediction of potential yield under future climatic conditions.

Workplan

- Dec. 1992: Collect data and adapt the model.
- Dec. 1993: Field experiment.
- Dec. 1994: Validation experiment.
- Dec. 1995: Demonstration and application.

7.3 Crop and soil management

7.3.1 Systems approach to irrigated-rice production: controlling invalid tillering and promoting spikelet and grain development

(Lu Jun)

Background

Panicle density, grain number per panicle and thousand grain weight determine rice grain yield. The number of panicles formed depends on the development of the rice plant in the early and middle growth stages. Rice tillering directly affects grain yield. Generally about 40% of the tillers at the maximum tillering stage are invalid (i.e. non-heading). Invalid tillers do not make any contribution to final grain yield and consume soil nutrients and photosynthesis products in the middle growth stage.

Controlling invalid tillering and promoting spikelet and grain development can be done through appropriate water management and nitrogen application practices in high yielding irrigated rice environments. This will promote effective stem growth, strengthen root activity, increase the percentage of head-producing tillers, increase grain number per panicle and increase ultimate rice yield.

Objectives

- Using systems analysis and simulation methods, a technical system of soil management for controlling invalid tillering and promoting the spikelet and grain development will be developed to increase rice yield.

- Operational guidance will be provided for appropriate water management and nitrogen application strategies for high yielding rice environments. This includes four targets:
 1. water irrigation and drainage scheme (date and duration for irrigation and drainage in different soil types and different crop growth stages);
 2. nitrogen application schedule (total amount, date and proportion for application);
 3. the optimum composition of the seedling age, seedling quality (per seedling weight) and planting density;
 4. increasing yield and income.

Workplan

1991-1993: Focus on the optimum composition of seedling age, seedling quality (per seedling weight) and planting density, and the relationship between this composition and rice tillering.

1. Collection of data from previous experiments and literature.
2. Experiment: observation of the percentage of head-producing tillers, percentage of grain-producing florets and thousand grain weight under different maximum tiller number treatment conditions.
3. Development of the MACROS-LID module with the pattern of tillering-heading-grain formation processes.
4. Field experiment for model validation.

1992-1994: Focus on irrigation and drainage scheme

1. Field experiment. The effects of high flooding and drainage on tillering, heading, flowering, grain developing, root growth and root vitality will be observed. High flooding will be induced in the middle and later stages of tillering; water drainage will be carried out in three stages: late tillering stage, heading initiation stage and maturing stage.
2. Field experiment to determine the relationship between green leaves losses and root vitality.
3. Crop growth model with soil water force function will be adopted to find the ideal irrigation and drainage schedule in rice production level 1 (without soil water balance analysis).
4. Field experiment to measure soil nitrogen dynamics and soil oxidation-reduction potential under drainage treatments.
5. Measurements of the hydraulic conductivity and water retention curve for three soil types to modify soil water balance model (MACROS:L2SS) with drainage; observation of soil moisture contents and potentials in the field to analyze soil water balance under drainage conditions.

6. Crop growth model and soil water balance model will be adopted (MACROS:L1D+L2C+L2SS) to get the irrigation and drainage schedule in rice production level 2.
7. Field experiment for the drainage schedule validation.

1993-1995: Focus on nitrogen application schedule

1. Collection of data; field experiment for the nitrogen three quadrant diagram.
2. Relationship between nitrogen uptake and soil water stress.
3. Using model L3C to determine the nitrogen application schedule.
4. Field experiment for validation.

7.4 Crop protection

7.4.1 Study on management-decision optimizing model of striped stem borer

(Zhihong Xu, Elsa G. Rubia (on yield loss), Jingyuan Xia (on population dynamics), Weihong Luo (on weather data) and Xingeng Wang (assistant for field experiment))

Background

Stem borer causes yield loss of rice. It is one of the most harmful insects in rice production in Zhejiang province. A lot of research has been done on population dynamics and yield loss due to striped stem borer in China and other Asian countries. The data are however difficult to use in an integrated analysis as they are taken in different environments, using different varieties and using different agricultural practices. Hence it is necessary to establish an integrated model, which can reflect population dynamics and yield loss due to the borer in any given habitat. A standard yield loss model for striped stem borer and a population dynamics model for yellow stem borer have been validated recently. Further work will be needed to combine in these two models and to validate the new integrated model.

Objectives and expected output

1. A damage model and a population dynamics model will be combined and adapted to establish an integrated model. This model will be used for simulation of realistic population dynamics and damage of the stem borer on rice under local weather and cropping systems.
2. Investigate how infestation date and larvae density affect yield loss.

3. Determine how well the rice plant is able to compensate damage due to stem borer through renewed tillering and if this is variety specific.
4. Investigate how drainage at maximum tillering stage affects tillering dynamics, hence yield loss.

The integrated model will provide:

- a better understanding of the effects of stem borer damage in the field;
- a quantitative prediction of the stem borer population density and resulting rice yield losses;
- a way to analyze experimental data from different sites.

Potential model users:

1. Plant protection and agronomy divisions of research institutes.
2. Plant protection stations.
3. State farms and collective farms.

Workplan

Several field experiments will be carried out.

General

- Moths will be kept on potted and caged rice plants to produce egg masses. The number of egg masses per day will be recorded. A total of 120 egg masses is needed in a single season plus an additional 30 spare egg masses.
- The experimental area is 240 m² (caged).
- Rice varieties: ZHE 733 (indica), IR64 for early rice, XIUSHUI 620 (japonica) for later rice, plant spacing 13.2*16.5, 5 seedlings per hill with ample nutrients and water (except specified otherwise).

Treatments and sampling (2 replications)

- Treatment 1: variety ZHE 733, regular drainage in maximum tiller stage.
 Treatment 2: variety ZHE 733, without drainage in maximum tiller stage.
 Treatment 3: variety IR 64, regular drainage.

Egg mass density: one per two square meters.

Infestation date: 10 days after transplanting.

Sampling will be carried out once every 5 days until flowering. Affected plants (dead heart) will be brought back to the laboratory for dissecting. Living larvae number and in-

star, pupae and pupal shell number, parasitized and dead larva number will be recorded. Tiller numbers of healthy, and suffering plants will be counted.

At harvest, biomass of dissected stem, leaf, panicle, grain, number of grains per panicle, plant height and leaf area will be determined for both healthy and suffering plants.

Data collection and analysis

a. Mortality factors

- physical (temperature, humidity, heavy rain, overflow);
- variety resistance (local variety, IR rice, hybrid rice);
- chemical control (formula, dosage, method, time);
- natural enemies (fungus in early spring, egg mass parasites *Trichogramma* spp. and *Telenomus* spp., larva parasites Ichneumonid and Braconid species, spiders);
- agricultural practice (mortality due to transplanting and harvesting).

b. Population dynamics

- Make life tables of stem borers at different rice growth stages using experimental data

c. Yield loss

Dynamics of dead heart and white head, weight partitioning biomass, number of grains per panicle, plant height, leaf area at harvest.

Adaptation of the model

- Adapt striped stem borer damage models for linkage, modify for egg mass and larvae density input.
- Adapt yellow stem borer population dynamics model for striped stem borer population dynamics.
- Combine stem borer damage model with population dynamics model into integrated stem borer model.
- Integrated stem borer model evaluation, validation and sensitivity analysis.

Time table

year	month	activity
1992	1-2	preparation
	4-8	field experiment (tentative), collection of literature, primary model adaptation
	9-10	data analysis of field experiment
	*11-12	linkage and adaptation of the model, further analysis of experiment data.
1993	*1-4	improvement of approaches for proposed, project, learn simulation technology, familiarize with population model.
	5- 6	preparation for field experiment.
	7-11	field experiment (later rice).
	11-12	experiment data analysis, evaluation and validation of the model.
1994	1- 2	validation and sensitive analysis.
	3- 4	preparation for field experiment.
	5- 7	field experiment (early rice).
	8-12	experiment data analysis and order, evaluation and validation of the model.
1995	*1- 6	further analysis of experiment data and simulation results, thesis writing, renew simulation skill. preparation for further plan.
	7-12	Administrative experiment and stem borer integrated model extension.

* to be conducted in Wageningen, others will be conducted at ZAU, China

8. Workplan of the Central Rice Research Institute

Central Rice Research Institute
Cuttack
Orissa 753006
India

The CRRI-SARP Simulation Team is composed of:¹

Dr. P.R. Reddy	Plant Pathologist (Team Leader)
Dr. S.K. Nayak	Plant Physiologist
Dr. R.N. Dash	Soil Scientist
Dr. K.S. Rao	Agronomist
Dr. M.V.R. Murthy	Soil Scientist

¹ At the time of Planning Workshop, March 1992.

Background

Out of the total rice area of 41 million hectares in the country, 23.8 million hectares (58%) are located in the eastern states of India, comprising the states of Assam, Bihar, West Bengal, Orissa, eastern Madhya Pradesh and eastern Uttar Pradesh. Average productivity of rice in the eastern region is only 1.8 tons/ha which may be due to a number of biotic and abiotic stresses the crop undergoes during the wet season (June-Dec). The biotic stresses include pests and disease damage. The abiotic stresses mainly concern weather and fertility levels of different nutrients required for crop growth. To increase the yields, it is imperative to identify the constraints and understand their impact on rice growth in order to improve or develop different plant types adaptable to various agro-climatic areas in the country.

The concept of developing a plant type is undergoing changes in time to overcome both biotic and abiotic stresses with the ultimate aim on improving yields. With this aim in view, the following proposals are made to understand the impact of stresses on the crop through the approach of simulation modelling.

8.1 Agro-ecosystems

8.1.1 Simulation and mapping of potential production zones in Eastern India

(M.V.R. Murty and S.K. Nayak)

Background

Out of the 41 million hectares of rice area in the country, 23.8 million hectares (58%) are located in the eastern states of India, comprising Assam, Bihar, West Bengal, Orissa, eastern Madhya Pradesh and eastern Uttar Pradesh. The average productivity of rice in the eastern region is only 1.8 tons/ha. This whole region is heterogeneous in nature in terms of environment, soils, and land situation. To increase the productivity and to bring stability of yields a systematic approach should be made available to the policy makers; hence an effort of agro-ecological zonation of this area by the integrated approach of combining information on soils, environment and crop simulation will give insights into the reasons for the yield variability as well as recommendation for reducing them and also maximum attainable reduction of the yield gaps.

Methodology

1. Collection, computerization and integration of the available data.
2. Simulation and presentation of simulation results.
3. Yield stability and variability analysis with dates of sowing, varieties etc.

Workplan

Data collection, pooling up of data and processing will be done simultaneously. After the completion of the potential production mapping an attempt will be made to workout the simulation of the water limited production with the help of the improved model. This will be done for various areas where there is no alternate source of water. These are predominantly monsoonal areas. In general the rainfall will be sufficient for a crop but the variability of the pre-monsoonal showers is a serious factor to be analyzed.

Expected output

Complete agro-ecological zoning study by the end of the project.

8.2 Potential production

8.2.1 Development of a new plant type tolerate to low-light stress (S.K. Nayak)

Background

Rice grows in different agro-climatic areas in India. There are a number of rice varieties under cultivation both traditional and improved suitable for different locations. The yield potential of different varieties depends upon their adaptability to a given climatic situation. Despite the release of a number of varieties in the recent years, the yields remained stagnant in the eastern states of India. This has been attributed mainly to the constrained light availability to the crop indicating the necessity of improving the plant type suitable/adaptable to low light conditions.

Estimation of various physiological parameters desirable for improved yields under low radiation levels is a pre-requisite to identify suitable varieties. Simulation modelling can be used as a tool to develop a concept of plant type with required physiological traits to obtain high yields.

Objective

Development of a new rice plant type adaptable to low light situations to the improve yield potential in eastern parts of India.

Approach

Various physiological parameters e.g. PLMX, SLW and dry matter partitioning, of different cultivars suitable for low light situations can be evaluated through simulation models and assess the potential yields of these varieties. A number of low light adaptable varieties are already identified and are under cultivation. The concept of plant type can be further improved to increase the yields, so that the breeders can take advantage of information available to develop improved rice cultivars.

The aspects to be considered for a new plant type are:

1. Varieties with leaf geometry for best light distribution should be identified keeping leaf angle and leaf thickness in view.
2. Plant height should not be less than 1.15 m with strong internodes to avoid lodging.
3. Varieties with high canopy photosynthesis under low light situations are desirable.
4. A functional relationship is to be developed between accumulation of pre-flowering reserves and remobilization at post flowering stage for better grain filling.
5. More grains per panicle are desirable than number of panicles per m².
6. Varieties with grain dormancy are desirable to avoid germination in the field.

An ideotype with these characteristics will be ideal to improve the yields under light constrained situations. The potential of the varieties can be tested with information available through simulation before being recommended for cultivation.

Expected Output

1. Crop parameters of different suitable rice varieties can be obtained for simulation.
2. The idea of location specific best plant type can be derived.

8.3 Crop and soil management

8.3.1 Nitrogen limited rice production: process research

(R.N. Dash and K.S. Rao)

Background

Process research in the theme of Crop and Soil Management is being conducted to develop a refined explanatory model (L3C) for the nitrogen limited rice production. It will be carried out mostly through literature search, field and laboratory experiments.

Approaches

Several aspects of N limited production are in the process of study during 1992-94 and they are all included in the theme proposals.

- a. Genotypic interactions with nitrogen: There is considerable variation among the rice varieties of different durations in terms of their response to nitrogen and yield potential. Through field experiments (during wet seasons of 1992-93) efforts will be made to generate crop data sets mainly the dry matter partitioning, photosynthetic rate, leaf area development, tillering and spikelet formation as affected by nitrogen supply for model development and for its validation.
- b. The response of an initially N stressed rice crop to nitrogen is studied in a field experiment in 1992, which is at present a network wide activity
- c. The concentration of mineral nitrogen in total soil-water complex is to be studied in 1992-93. A simple dynamic/empirical model will evolve from this process.
- d. Comparison of the results of the above experiments with the results of similar experiments conducted by several researchers inside and outside the SARP network. This will be a basis for providing inputs for further refinement / development of the model. It is proposed to take-up this activity in the third year of the SARP project.
- e. Validity of the developed/refined model will be tested through experimentation in 1993-94 as well as with existing data. It will be tested mainly on timing, method and N fertilizer application.

8.3.2 Nitrogen limited rice production: applied research

(R.N. Dash and K.S. Rao)

Background

In the fourth year of the SARP project a recommendation of optimum N application relating to its timing, amount, form and method will be developed based on above simulation research. This will be tested against the current practice in several locations of the Institute farm and at cultivators fields with or without water limitation.

Research activities that do not fit in framework of research proposals:

Preparation of a data base of crop characters of several cultivars and a soil data base for NH_4 concentration in the flooded soil and to group them on the basis of similarity. This will be helpful for the formulation of recommendations of optimum N application with respect to different cultivars.

Time allocation

About 50% time of each of the scientist will be devoted to systems research using simulation models during the project period of SARP-III.

8.3.3 Water limited rice production: process research (M.V.R. Murty)

Background

Experiments on the crop response to water stress are in progress.

Approaches

Detailed field experiments and pot experiments will be conducted to find out the effect of water stress on the crop response. Efforts will focus on the response of the rice crop in a relatively stress tolerant as well as stress sensitive rice cultivars. Stress at max tillering to panicle initiation stage will be characterized and the crop response will also be quantified in terms of crop data inputs to the model. Experiments will be aimed at the crop response towards the sink-source relationships.

There is already some information available from which working relationships will be developed.

The data generated will be utilized to test the current MACROS models and in the further development of the models. Experimentation and improvement of the model will go on simultaneously.

8.3.4 Water limited rice production: applied research

This effort is aimed at the optimal utilization of the water resources in the recommendation of the management practices keeping in view the variability in the rainfall patterns and the timing of the alternate sources of irrigation.

8.4 Crop Protection

8.4.1 Quantification of the effects of bacterial blight and sheath blight diseases on crop growth and yield of rice: process research (P.R. Reddy)

Background

From among the leaf damaging diseases of rice, bacterial blight and sheath blight are chosen for simulation studies under SARP-III.

Approaches

Research activities included in this programme are:

- identification and quantification of damage mechanisms;
- introduction of data into the crop growth model: the data collected for damage mechanisms in the field experiments will be used for simulation modelling.

Bacterial blight

Damage mechanisms may either affect the rates of leaf photosynthesis and respiration or shading of dead leaves over neighbouring healthy leaves. Experiments are in progress for the measurement of photosynthetic rate and respiration under different levels of lesion development.

Concerted efforts were made during the last few seasons in several field experiments to collect the data on leaf area (healthy, diseased and dead) at different levels of leaf canopy. Dry weights of leaves, stems and panicles and total grain yield were also estimated.

Sheath blight

Sheath blight disease induces the symptoms of blighting of leaves and leaf sheaths ultimately resulting in the death of affected tillers. Panicle emergence in the affected tillers may be delayed resulting in the spikelet sterility.

Field experiments are being planned to collect the data on:

- onset of the disease;
- monitoring of the disease progress at weekly intervals;
- crop growth data on ALV, WLV, WST, WSO, PANNUM, SPINNUM;
- rate of photosynthesis and respiration in leaves infected with different degrees of disease severity.

8.4.2 Quantification of the effects of bacterial blight and sheath blight diseases on crop growth and yield of rice: Applied research (P.R. Reddy)

Background

We intend to participate in the applied research through identification of selection criteria for reduced yield loss.

Experiments to collect data on infection efficiency, and lesion growth rate for bacterial blight and sheath blight diseases under different host-pathogen interaction may need to be conducted. Different rice varieties differing in degrees of susceptibility may need to be

included. At least two or three levels of nitrogen if included might help in understanding the *variety/nitrogen interaction on infection efficiency and rate of lesion development*.

Results of such studies may lead to advise the farmers on the levels of nitrogen to be applied for different varieties under cultivation to obtain optimum levels of grain yield.

8.4.3 Quantification of the effect of rice tungro virus on crop growth and yield of rice (not within SARP proposal framework).

(P.R. Reddy)

Background

Serious epidemics occur in certain years whenever leaf hopper population coincides with vulnerable stage of crop growth. It manifests in inducing yellow to orange colouring to the leaves leading to stunted growth and poor panicle emergence resulting in reduced grain yield.

Approaches

In a field experiment it is proposed to collect data on:

1. disease initiation and rate of progress;
2. estimation of ALV, WLW, WST, PANNUM, SPINNUM;
3. rate of leaf photosynthesis and respiration as inputs for damage mechanisms;
4. incorporation of the data into the model.

Time allocation

Planning to devote 50-75% of time for systems research under SARP-III.

9. Workplan of the G.B. Pant University of Agriculture and Technology

G.B. Pant University of Agriculture and Technology
Pantnagar
District Nainital 263 145
Uttar Pradesh
India

The PUAT-SARP Simulation Team is composed of:¹

Dr. J.S. Sharma	(Team supervisor)
Dr. B. Mishra	Soil Scientist (Team leader)
Dr. R.A. Singh	Plant Pathologist
Dr. P.K. Pathak	Entomologist
Dr. M.P. Pandey	Rice Breeder
Mr. Bhagwan Das	Plant Pathologist
Dr. Pyare Lal	Agronomist

¹ At the time of Planning Workshop, March 1992.

Introduction

Uttar Pradesh is one of the most important rice growing states in India. Rice is grown in the wet season (kharif) of the year in about 5.5 million hectares but the productivity is low, 1.2 t ha⁻¹. The productivity in the western districts is much higher than in the central and eastern part of the state. There are several constraints in rice production such as delayed planting, nutrient stress, incidence of diseases and insect pests etc. In order to assess the relative significance of different constraints in rice production, the university has to invest a lot of resources in conducting field trials and on-farm demonstrations every year. These trials and demonstrations are repeated year after year to take care of weather variability and its influence on the crop performance and input use efficiency. Use of simulation models as research tool would be greatly helpful in ascertaining the role of each factor as well as interactions of various factors in rice production.

Simulation studies started at Pantnagar in 1986 when a team of four rice research scientists of the university participated in the training course on systems analysis and simulation for rice production held at Wageningen, Netherlands. In 1990 two more rice scientists received the same training at IRRI and joined the team.

Goals

1. Delineation of potential production zones for different rice cultivars in the plains and hills of northern India.
2. To develop a simulation model for predicting the response of rice to fertilizer nitrogen under different soil, crop and water management conditions.
3. To develop models for understanding damage mechanisms caused by insect pests and diseases of rice and to develop simple decision making rules for management of pests and diseases.

9.1 Potential production

9.1.1 Simulation of potential production of rice cultivars

Background

The yield potential of rice varieties differs from one location to the other. Therefore it is necessary to know the yield potential of each rice variety at several locations in the state/country before it is released for cultivation. This requires extensive field evaluation trials to be conducted at various locations for several seasons. Use of a simulation model for determining the production potential of rice varieties would be greatly helpful in deciding the areas where a given variety should be evaluated.

Objectives

1. To simulate the potential production of rice cultivars of varying duration for several locations in the north Indian conditions.
2. To design new plant types for the plains and hills of northern India.

Approach

The model L1D will be adapted with respect to four rice cultivars viz: Pant Dhan 4, Jaya, Manhar and Rasi. The adapted model will be used to simulate the potential yields of rice varieties for diverse environments in north western plains of the state. Weather data of Pantnagar, Meerut, Bareilly, Ranichauri, Majhera and Delhi will be utilized for this purpose.

Expected output

The results of simulations will help deciding the areas where a given rice variety would give expected yields. This would reduce the number of field evaluation trials which otherwise would be required to be conducted at different locations. The results may also be used as reference for field measurements and thus setting goals for potential production.

Using the simulation model new plant types for achieving higher yield potentials would be designed and rice breeding programmes will be reoriented to introduce the desirable traits of the new plant type.

9.2 Crop and soil management

9.2.1 Development of soil-plant nitrogen dynamics module of rice growth model

Background

Nitrogen is a key factor in limiting rice production. Though use of nitrogen fertilizers has been increasing, its efficiency for rice production is low, seldom exceeding 40 per cent. This leads to not only waste of nitrogen fertilizers but also environmental pollution. There is a possibility of increasing the use efficiency of nitrogen fertilizers in rice by matching the schedule of fertilizer application with crop demand. The fertilizer need for the crop will however depend on the soil nitrogen availability and extent of loss of the applied fertilizer which are influenced by several factors relating to soil, crop and weather. Use of

simulation models will therefore be helpful in developing appropriate fertilization schedules for different soil-crop-weather situations.

Objectives

1. Prediction of rice response to nitrogen supply under different soil conditions, crop establishments and water management.
2. To develop appropriate nitrogen management strategies to optimize the use of nitrogen fertilizers.

Approach

In the plant nitrogen dynamics component of the rice growth model further refinements in the following aspects will be done:

1. Effect of nitrogen stress on biomass partitioning.
2. Grain filling related to protein content of the grain.
3. Specific leaf weight related to N content.
4. Senescence of leaves, stem and roots related to the N status of the plant organ.

In the soil nitrogen dynamics component the following aspects will be improved:

1. Nitrogen uptake related to the root length density and concentration of available nitrogen in the root zone of the soil.
2. Nitrogen loss related to depth of flood water, duration of flooding and percolation rate in the soil.
3. Ammonia volatilization related to the wind velocity, flood water alkalinity and ammonia concentration.
4. Denitrification loss related to nitrate formation and its diffusion into the reduced soil zone.
5. Soil N mineralization related to the amount and nature of the organic matter.
6. Transfer of nitrogen between soil and flood water and between reduced zone and oxidized zone.

Field data on N content of leaves, stem, roots and grains and the nitrogen balance in the rice-soil system using ^{15}N as tracer have been collected during 1987 and 1988. These data will be used for validation of the model. Finally, a summary model will be developed for use in the formulation of nitrogen management strategies under the following conditions:

1. Soils of varying nitrogen mineralization potential.
2. Water management levels; flooding depth, duration of flooding and percolation rate.
3. Planting spacing, time of transplanting and age of seedlings.
4. Rice varieties of different duration and root activity.

Expected output

The validated model can be used to predict the response of different rice cultivars to various nitrogen management strategies. Alternative management practices for optimizing the use of nitrogen fertilizers can be worked out. With help of the model, optimum time and quantity of nitrogen fertilization for different soils, crop varieties and weather conditions can be recommended to the farmers for most efficient and profitable use of nitrogen fertilizers.

9.3 Crop Protection

9.3.1 Simulation of potential yield losses due to sheath blight and bacterial leaf blight

Background

Sheath blight of rice caused by *Rhizoctonia solani* has attained epidemic proportions in certain parts of the state causing significant losses in yield. The mechanisms of loss caused by the pathogen have not been worked out, but a 25% loss in yield has been reported under moderate condition of disease. Most of the cultivated varieties are susceptible to the disease and there is no feasibility of achieving a resistant variety in the near future in the absence of a resistant donor against the disease. In the absence of resistant varieties, cultural practices and the use of effective fungicides are the only option left to manage the disease at farmer's field level. Estimation of potential losses caused by the disease at different intensity would be of great help in making the decision for supervised control of the disease.

Bacterial leaf blight is another important disease prevalent in the area which causes loss in the rice yield. The relationship between the extent of yield loss and the disease severity has not yet been quantified.

Objectives

1. To identify and quantify the damage mechanism in sheath blight and bacterial blight of rice, especially reduction in leaf photosynthetic rate under different severity of the disease.
2. To develop an epidemiological model and simple decision making rules to manage these diseases.

Approach

A. Process Research

The field experiment conducted during Kharif 1991 will be repeated during Kharif 1992 with Pant Dhan 4 to confirm the extent of loss due to sheath blight at different degrees of disease intensity. The model will be validated.

Input and output data for the model will be collected to identify and quantify the damage mechanism, especially reduction in leaf photosynthetic rate at different severity of the disease.

Input

- a. Leaf area index.
- b. Fraction healthy/diseased/dead leaf area.
- c. Disease severity.
- d. N-content.
- e. SLA.

Output

- a. Total shoot dry weight.
- b. Distribution of dry weight over leaf/stem/panicle.

The data will be incorporated in the L1DFDE model and the extended model will be validated. For sheath blight, it is assumed that the diseased leaves have no shading effect while shading effect by diseased leaves in bacterial leaf blight will be taken into account.

B. Applied research

The rate of development of the pathogen in few selected varieties grown at different N levels and weather conditions would be studied to develop an epidemiological model. Efforts would be made to develop simple decision making rules for supervised management of the disease so that excessive use of fungicide is avoided and at the same time farmers do get economic benefit.

Expected output

Once the damage mechanism of these diseases is known and the model is validated, it will be easier to predict the loss and to advise the farmers how to manage the disease. With the judicious use of fungicides, the profitability of the farmers will be enhanced and at the same time pesticide pollution will be minimized.

9.3.2 Simulation of rice yield losses caused by yellow stem borer

Background

The stem borer has become one of the most important insect pests causing serious damage to the rice crop in the area. The damage to rice in the 1990 season was up to 60% (white heads) in some of the rice varieties and 30-40% dead hearts at tillering stage. A wide range of losses due to stem borer have been reported by various workers. Experiments conducted at the university and elsewhere indicated that the yield losses at 10-15% dead hearts damage are not significant. The economic threshold level (ETL) of 8-10% dead hearts recommended at the national level is too low for the Tarai region where rice productivity is high. The ETL varies with location, type of rice varieties, stage of the crop at the time of infestation and weather etc. To establish ETL for different locations and varieties a large number of experiments would be required demanding a lot of resources and also it would take a long time. Use of computer simulation model would be greatly helpful in this task saving scarce resources as well as time.

Objectives

1. To assess yield losses at different levels of dead heart damage.
2. To assess yield losses at different levels of white head damage.
3. To ascertain the effect of dead hearts and white heads on other uninfested tillers.
4. To establish economic threshold levels for the control of the stem borer in the Tarai region.

Approach

The study on stem borer damage is to be continued in the next years. The results of the simulation for the tillers and dead hearts will be compared with the observed data. The model will be adapted to sort out the differences between the simulated and observed values. The following parameters will be specially looked at:

- a. Leaf area index.
- b. Number of tillers.
- c. Number of flowers.
- d. Number of filled and unfilled grains.
- e. Weight of individual grains.
- f. Time coefficient for formation and degeneration of tillers.
- g. Time coefficients for formation of grains.
- h. Nitrogen content of leaves.

Simulation studies will be carried out to determine the yield loss due to whiteheads as well as the shading effect of white head bearing tillers on healthy tillers. Necessary field data have been collected during 1990, which will be analyzed. The simulation results will be evaluated using the field data and the LIDTSB model will be adapted , if necessary, for realistic simulation.

To collect critical information regarding the effects of dead hearts and white heads on the healthy tillers, two separate field experiments were carried out in 1991 and 1992. In 1993 a field experiment will be carried out to ascertain relative contribution of the white-heads tillers to the healthy tillers under artificial infestations. In these experiments the number of seedlings per hill will be strictly regulated to one keeping the conditions of the field experiment the same as in previous years.

Expected output

The results of the field experiments and simulations are expected to help the plant protection specialists to predict the losses at various levels of infestation and also decide the economic threshold levels of stem borer damage in different areas so that timely control measures can be advised. It will also help in minimizing the excessive use of pesticides and in reducing the cost of rice cultivation at the farm level.

10. Workplan of the Water Technology Centre

Water Technology Centre
Indian Agricultural Research Institute
New Delhi 110012
India

The IARI-WTC SARP team is composed of:¹

Dr. P.K. Aggarwal	Crop Physiologist (Team Leader)
Dr. Naveen Kalra	Soil Physicist
Dr. N.H. Rao	Hydrologist
Dr. A.K. Singh	Soil Physicist

¹ At the time of Planning Workshop, March 1992.

Background

Rice and wheat are the major cereal crops of India. The two crops are extensively grown in rotation: rice during the rainy, warmer season and wheat during the dry, winter season. The area under this rotation can be classified in three major zones:

Zone 1: - Punjab, Haryana, Delhi, West Utter Pradesh

- Coarse - medium soils
- Irrigated area
- Pronounced seasons
- Semi-arid
- Main problems: decreasing yields, rising water table and increasing salinity due to improper use of irrigation water

Zone 2: - Andhra Pradesh, Eastern Utter Pradesh, Bihar

- Medium - fine textured soils
- Irrigated / partially irrigated / rainfed areas
- Pronounced seasons
- Main problems: sub-optimal inputs

Zone 3: - Bihar, West Bengal, Assam

- Medium - fine textured soils
- Partially irrigated and rainfed areas
- Sub-humid
- Main problems: low and unstable yields due to sub-optimal inputs

In all the zones, growth and yield of wheat in rice-wheat rotation is affected by cultural practices followed for growing rice. In general, wheat sowing gets late due to delayed harvest of rice and/or long turnaround time. Soil water balance during growth of wheat behaves differently due to changes in retention and transmission characteristics of water in the profile. The optimisation of wheat yield under paddy-wheat cropping system requires thorough understanding of wheat growth response in terms of water use, nutrient uptake and root and shoot growth arising due to varying moisture, nutrient, soil and climatic conditions. The present study is an attempt to simulate soil and crop growth processes by incorporating soil-plant-atmosphere inter continuum components.

Objectives

- Mapping of potential production zones for different rice and wheat cultivars as influenced by soil types, weather conditions and phenological behaviour.
- Wheat productivity analysis under varying levels of water and nutrient supply situation.

- Parameterization of physical and physiological characters of crop and soil for WTGROWS model validation.
- To improve simulation of soil water and nitrogen balance for wheat grown under varying soil and climatic situation.
- To implement system simulation for evaluating the impact of climate change on growth development and yield.
- To develop models for defining and quantifying the damage relationship of insects, pests and diseases of wheat.

Approach

Major lines of work

1. Formulation, calibration and validation of nitrogen balance as a subroutine for WTGROWS.
2. Improve simulation of soil water balance in relation to water uptake from various soil layers, evaporation losses from the soil under crop canopy, water table contribution towards crop water use, etc.
3. Screening of different wheat and rice varieties under varying agro-climatic situations.
4. Conduct field experiments on topics where data is inadequate, such as regulation of sink size, partitioning, senescence, evaporation loss from soil surface, crop coefficients etc.
5. Assessment of growth response as influenced by gradual climatic changes viz. global warming.
6. Translate WTGROWS in FORTRAN for enhanced interaction and adaptability.

Methodology

- Survey of literature for integration of available data.
- Experiments to be conducted on the aspect of inadequate data.
- Improvements in WTGROWS on various aspects such as incorporation of soil water and nitrogen balance sub-routines by using existing models as well as incorporating the knowledge gaps.

Workplan

Data generation and model development will be carried out simultaneously during the proposed period of investigation.

Expected Output

The investigation aims at more realistic assessment of soil and plant processes which would subsequently result in adoption of various optimisation procedures for maximising yields under varying soil-plant-atmosphere interactions.

11. Workplan of the Tamil Nadu Rice Research Institute

Tamil Nadu Rice Research Institute of
Tamil Nadu Agricultural University
Aduthurai 612 101
Tamil Nadu
India

The TNAU-TNRRI Simulation Team is composed of:¹

Dr. A. Abdul Kareem	Team Supervisor
Dr. S. Palanisamy	Plant breeder (Team Leader)
Dr. V. Narasimhan	Plant pathologist
Dr. T.M. Thiyagarajan	Soil Scientist
Dr. S. Mohandass	Crop physiologist
Mr. N. Raju	Entomologist
Mr. M.N. Budhar	Agronomist
Dr. Kempu Chetty	Weed Scientist

¹ At the time of Planning Workshop, March 1992.

11.1 Agro-ecosystems

11.1.1 Evaluation of rice genotypes for their potential production in different agroclimatic situations of Tamil Nadu by simulation

(S. Palanisamy, T.M. Thiyagarajan and M.N. Budhar)

Background

In Tamil Nadu at present rice is grown in all the seven agroclimatic zones in 22 m ha with a total rice production of 62 mt (1989-90). The target of rice production is 100 mt for 2025 AD. Since the cultivable area is shrinking year after year the only possibility to achieve the production target is by increasing the productivity per unit area. Though modern rice varieties yield high, the potential production of these are varying mainly due to variability in soil characteristics of different agroclimatic regions. Rice yields in some zones are high but the factors responsible have not yet been assessed. The use of models will aid to predict the potential yield of rice variety by using data on variability in soil characteristics in Tamil Nadu.

Approaches

Modules such as LID, L3C will be used with suitable modifications based on field experiments.

Objectives:

- General : To develop and make available better and more reliable techniques for crop improvement
- Specific : To find out the use of models for determining crop production in different agroclimatic zones (by using the weather data and also by deriving relevant soil data)

Program of Work

A:

1. Collection of weather data from the different rice research stations in different agroclimatic zones of Tamil Nadu, i.e., Aduthurai, Ambasamudram, Bhavani Sagar, Coimbatore, Madurai, Paiyur, Paramakudi and Tirur.
2. Conducting field experiments at Aduthurai with popularly grown high yielding rice varieties of short (110-120 days) and medium (135-145 days) duration with different

dates of planting for collection of crop data besides laying out observational trials in different sites to obtain yield data.

3. Simulating the growth of both short and medium duration rice varieties in different locations for model validation.

B.

1. Collection of soil data in different agro-ecological zones from different research stations.
2. Simulating the growth of both short and medium duration rice varieties in different locations for model validation with optimum N application.

Plan of work

Field experiments to collect crop data at Aduthurai and observation trials at other stations	}	short duration Jun. - Sept. '92, medium duration Sep. - Jun. '93
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Interpretation by simulation Feb. - Apr. 93

observation trials in specific locations based on simulation	}	short duration Jun. - Sept. '93, medium duration Sep. - Jun. '94
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Interpretation by simulation Feb. - Apr. 94

Prediction for adoption Jun. - Sep. 94

Expected output

- Crop data for various varieties and weather data for number of years will be available.
- Grain yield data over locations, over years for Tamil Nadu will be available.
- Data for screening of varieties suitable for specific locations.
- Identifying best time of planting in each agro-ecological zone to get maximum productivity.
- Thus high productivity zones can be identified and concentrated for achieving the target of rice production in Tamil Nadu by using the simulation models.
- Fixing optimum planting time for future varietal evaluations.

11.2 Potential production

11.2.1 Simulation in Pre-testing of Rice genotypes in Tamil Nadu

(S. Palanisamy)

Background

In Tamil Nadu rice production in 2000 AD is targeted at 9.0 mt. This could be achieved by increasing the production per unit area corresponding with an average yield of more than 4.0 t/ha. Most rice varieties, bred or introduced, yielded more than 10 t/ha of grain in certain parts of the State where intensive cultivation was followed with favourable weather but elsewhere the yield is only 7-8 t/ha. In fields of progressive farmers such varieties are expected to yield at least 60% of the potential yield level. Closing the yield gap therefore provides sufficient opportunity for yield increases. In breeding, the process of development of rice variety takes a minimum period of 8 years while pre-testing of rice genotypes under multilocation trials alone involves a three year period. It would be possible to reduce the period of multilocation testing from 3 years to one year by use of simulation models.

Objectives

1. To predict the ranking for potential production of pre-release rice genotypes of short and medium duration under MLT at TRRI, Aduthurai.
2. To predict the ranking for potential production of pre-release rice genotypes under MLT at seven other locations in Tamil Nadu.
3. To predict the potential production of selected rice genotypes from MLT for advancing to ART.

Approaches

L1D and L1Q modules from the MACROS model.

Program of work

1. Collection of weather data from the eight rice research stations of Tamil Nadu.
2. Conducting field experiments at Aduthurai to collect crop data for parameterization of rice genotypes and laying out observational trials in other sites.
3. Simulating the growth of genotypes in all eight sites for model validation.

Time table

June 1992 -Oct 1992: Short duration MLT prescribed for 1992-93 for Aduthurai and other seven locations.

11.3 Crop and soil management

11.3.1 Optimization of nitrogen application to rice

(T.M. Thiyagarajan)

Background

Nitrogen is one of the major limiting factors in the yield of rice. The time and level of N application adopted by farmers vary from the normal recommendations due to use of aged seedlings, non availability of water and labour at the appropriate time besides socio-economic factors . Also, the current knowledge on N partitioning, optimum dose and time of application in relation to crop phenology need to be expanded. The existing model L3C is to be improved by incorporating the changes needed for contingent situations.

Objectives

1. To study the nitrogen uptake and distribution in rice in relation to growth stage and quantity of N application.
2. Develop the existing L3C model to optimize N application in specific phenological stages of rice crop for maximum yield.
3. Evolving contingent N application strategies for aged seedlings, sub optimal N application during vegetative phase and economic constraints of farmer using the revised L3C model.

Program of work

1. Conduct field experiments with different times and level of N application; seedling ages and water limitation.
2. Collect plant sample for N and C partitioning.
3. Improve the L3C model to suit contingent situations and validate.

Workplan

Field experiments and collection of data	1992 & 1993
Model improvements and validation experiments	1994

Expected output

Formulation of optimum N application strategies for normal and contingent situations in rice by simulation.

11.3.2 Simulation of effect of late N application on growth and yield in rice

(S. Mohandass)

Background

There is a definite yield decline under continuous rice cropping. The reason attributed for this is poor nutrient management especially nitrogen. Recent studies stress that late application of N could off-set this decline. Hence, there is a need to concentrate on the late N application research in order to raise the yield plateau.

Objectives

1. To find out the effect of late N application on transplanting shock, tillering, grain formation and leaf senescence.
2. To improve the existing L3C module for better performance.

Program of work

The effect of late N application will be studied on:

1. Transplanting shock
2. Tillering behaviour
3. Leaf area development
4. Photosynthesis & respiration
5. Source-sink relationship
6. Grain filling characteristics
7. Leaf senescence behaviour

Plan of work

Activity	Period
1. Conducting field experiments, collection of crop data	June 1992-June 1993
2. Model development & running the model	July 1993-Dec. 1993
3. Finalizing the results, validation & reporting	Jan. 1994-June 1994

Expected output

A realistic model will be built to study the effect of late N application on growth and yield of rice. This will be utilized to determine optimum N concentration in leaf for different groups of rice.

11.4 Crop protection

11.4.1 Simulation of leaf folder damage in rice and its relationship to yield loss

(N. Raju)

Background

Leaf folder is one of the major pests of rice causing damage to the crop during various developmental stages. The severity of the damage is alarming when the damage is seen in the maximum tillering and panicle initiation stages. The yield loss relationship was documented by Bantista et al., 1984; Miyshita 1985 and Panda et al., 1987. The simulation of population model of rice leaf folder coupled with rice crop growth model by Benigno et al., 1987 gives guidelines for the study. This approach could be used to simulate both insect population and plant growth and predict the timing of population peaks and ETL spray schedules.

Objectives

1. To quantify the effect of leaf folder damage in relation to the dry matter production.
2. To develop pest control model relating to the economic threshold level on different developmental stages of the crop.
3. To find the effect of N-levels on the rice leaf folder damage and its relationship to the total dry matter.

Program of work

1. Conduct field experiments to quantify the effect of leaf folder damage at different crop growth stages and larval population level.
2. Conduct a field experiment to study the effect of N-levels on rice leaf folder damage and its relationship to total dry matter.
3. Sensitivity analysis and validation of the model.
4. Develop pest control model relating to the economic threshold level on different development stages.

Plan of work

- 1992 - 93: Quantification of leaf folder damage in relation to total dry matter.
- 1993 - 94: Pest control model development for ETL on different growth stages of rice.
- 1995 - 96: N-levels with leaf folder damage relationship.

Simulation and validation of the model.

Expected output

The effect of leaf folder damage on the rice crop growth at different stages and its effect on leaf area, carbohydrate partitioning and photosynthesis can be derived.

The economic threshold level of the leaf folder damage to the rice crop can and the optimal level of N application will be determined.

11.4.2 Simulation of yellow stem borer damage in rice and its relationship to yield loss

(N. Raju)

Background

The yellow stem borer *Scirpophaga incertules* (walker) causes damage to the rice crop during its larval stages. The damage caused was worked out in relation to yield loss by Israel and Abraham (1967). They found that for every 1% increase in stem borer infestation during early stages and at reproductive stages, there was a decrease in yield of 0.28 and 0.62% respectively.

At IRRI Philippines a regression model showed that every 1% increase in dead hearts and white ears results in a decrease in yield of 1.6% and 2.2% respectively.

The above research indicates an estimate of the entire crop growth period. There is no clear indication at what time of the crop period or at which stage loss is taking place and its relationship to yield. Hence, to develop a crop growth model the simulation and system analysis (Penning de Vries and Van Laar, 1987) for crop growth is to be adapted and the damage relations are to be fitted by obtaining the relevant crop parameters.

Objectives

- To develop a stem borer damage model relating to the economic threshold level at different crop growth stages.
- To find the effect of different levels of N-application on stem borer damage and its relationship to yield.
- To find the effect of plant spacings on stem borer damage and its relationship to yield.

Program of work

1. Conduct field experiments to find the economic threshold level for stem borer with different egg mass introduction at different stages of crop growth.
2. Conduct field experiments to find the effect of different levels of N-application and plant spacing and their relationship to stem borer damage.
3. Parameterization and validation of the model.

Expected output

The damage due to stem borer and the yield loss during various development stages of the rice crop can be predicted.

The economic threshold level for different stages of the crop can be spelled out.

The N-levels and spacings and their influence on stem borer damage can be seen.

Plan of work

Activity	Period
Developing a model relating to economic threshold level	1992 - 93
Developing N-levels relationship to stem borer	1993 - 94
Developing a model for planting density in relationship to stem borer damage	1994 - 95
Model validation	1995 - 96

11.4.3 Simulation of yield loss due to blast damage

(V. Narasimhan)

Background

Blast is an important disease of rice causing severe yield loss. Several workers have estimated losses due to this disease ranging from 5-80 percent depending on the season, variety and locality (Padmanabhan, 1965, Muralidharan and Venkata Rao, 1980). However, it is essential to predict the yield loss due to this disease when infected at different grades of infection. Initial studies were made to develop a model for simulation of yield loss due to blast based on the MAROS/L1D model (Bastiaans, 1991). The program envisages the standardization of the model at different infection levels and in selected resistant and susceptible cultivars.

Objectives

1. Simulation of yield loss due to blast disease at different intensities of infection.
2. Study the effect of blast infection in selected resistant and susceptible cultivars as yield loss and simulation.

Program of work

1. The standard MACROS/LID model with physiological parameters introduced as a function of the fraction of disease.
2. Field experimentation to study the effect of blast at different levels of infection on yield and simulation.
3. Study the effect of disease on cultivars of different grades of susceptibility.

Plan of work

Study the effect of blast at different intensities and developing model	1993-94
Study the effect of infection in selected cultivars of different grades of susceptibility	1994-95
Model validation for blast	1995-96

Expected output

Yield losses due to blast damage at different levels of infection and in varieties different grades of susceptibility can be quantified and predicted by developing a simulation model.

11.4.4 Simulation of yield loss due to bacterial blight damage

(V. Narasimhan)

Background

Foliar diseases like Bacterial leaf Blight (BLB) cause severe damage to rice crop. Yield loss varying from 2-74 percent due to BLB (Ahmad and Singh, 1975, Reddy et al., 1979) have been reported. However, the values are not so precise to predict the yield loss at specific infection period and for different cultivars of short and medium duration. Initial studies were conducted on Simulation of BLB damage as a function of leaf photosynthesis and respiration (Narasimhan et al., 1995; Reddy et al., 199). The standardization of the model MACROS/LID with suitable modification taking into account the physiological functions related to infection at different layers of the crop canopy is being taken up under

the SARP net work. The program now envisaged is a continuation of the above line of work.

Objectives

1. Simulation of crop loss due to BLB damage at different stages of crop growth.
2. Study the loss due to BLB infection in selected medium and long duration cultivars.

Program of work

1. The standard MACROS/L1D model developed by Penning de Vries et al., (1989) will be used and the necessary physiological parameters like leaf photosynthesis and respiration as a function of fraction of disease will be introduced.
2. Field experimentation using selected medium and short duration cultivars will be conducted.

Plan of work

- 1992-93: Developing a model for BLB damage when infected at different crop growth stages.
- 1993-94: Study the effect of loss due to BLB in selected cultivars and simulation.
- 1994-95: Study the effect of BLB on different cultivars on BLB infection and simulation.
- 1995-96: Model validation.

Expected Output

Yield losses due to BLB damage at different stages of infection and on different types of cultivars can be quantified and predicted by developing a simulation model.

12. Workplan of the Water Technology Centre

Water Technology Centre
Tamil Nadu Agricultural University
Coimbatore 641 003
Tamil Nadu
India

The WTC-TNAU SARP team is composed of:¹

Dr. Rajagopal	(Team Supervisor)
Dr. K. Palanisami	Agricultural Economist (Team Leader)
Dr. M. Selvarajan	Soil and water conservation
Mr. S. Ramasamy	Agronomist

¹ At the time of Planning Workshop, March 1992.

Background

Irrigation water is vital to Indian economy. Irrigation systems of India relieves agriculture from its dependence on erratic monsoons. In India 57.01 mha were irrigated in 1981 out of a total cropped area of 172 mha. India's maximum feasible irrigation potential is 113 mha, nearly double the 1981 level. In an effort to encourage the development Rs 93 billion in major medium and minor irrigation projects. In the Seventh Five Year Plan Rs 169.79 million are to be spent on irrigation and flood control representing 9.4% of the total plan outlay.

The tank system of Southern India and Sri Lanka are centuries old. They account for over 30% of the total irrigated area of Tamil Nadu, Karnataka and Andhra Pradesh states of South India; over 40% of the irrigated rice are in Northeast Thailand. These tanks are mainly used to irrigate rice during the late monsoon to early dry season from September through December.

Several constraints limit the productivity of these tanks. These include factors related to weather, surface and ground water storage, crop and farmer. The government is committed to implement methods (system modification and management) to improve water availability both at the tank and farm level. Hence it becomes necessary to study the options available to improve the performance of the existing systems.

Previous attempts to study these systems performance were mostly related to empirical solutions. These solutions varied widely from location to location. However, it is possible to develop systems approach which is generally applicable over all tank systems. This could be done by linking several modules vis crop, hydrologic (ground water), and economics models. Then this would serve as a decision support system for tank performance evaluation.

Approach

Summary of different models interfaces and out outputs are presented in the lower table. The base simulation model has the following variables and improvement strategies.

Variables and models	Strategies
1. Weather and surface hydrology	
rainfall	
run-off	
evaporation	
seepage	

Table continued next page.

Table continued

Variables and models	Strategies
2. Groundwater depth of wells number of wells distance of wells	
3. Crop single crop water requirements stress days yield reductions	1. sluice modification 2. sluice management 3. canal lining 4. additional wells
4. Farmer crop production income	
5. Time period: one year	
6. Number and type of tanks: non-system tanks	

In the first phase of model improvement, the following aspects are being attempted for inclusion in the base model:

1. A ground water model which limits the catchment/command area responses to the states of ground water.
2. Presentation of deficit irrigation in the crop model SAWAH.

Keeping into account the importance of further refinement, the following improvements are planned to be included in the next phase (1991 - 95):

1. Statistical future weather data generation.
2. Inclusion of small components to the crop/hydrologic models.
3. Studies on ground water pollution due to excess fertilizer application.
4. Adoption of the crop models with reference to crop sequence in these irrigated areas.
5. A simultaneous equation economic model to study production changes and income changes of the farmers.

Base model	Current modification	Future works	By
Weather and surface		date	agronomist
hydrology	-	generation	engineer
weather	-		
runoff	-		
seepage	-		
evapotranspiration	-		
water balance	-		
Groundwater			
depth of wells	-	inclusion of	engineer
number of wells	modified	pollution	
distance of wells	-	model	
Crop			
single crop	-	multi-crop	agronomist
water requirements	-	SAWAH model	soil scientist
stress days	modified		
yield reduction	-		
Farmer			
crop production	-	simultaneous	economist
income	-	equation syst.	
Time period	-	more years	all
Number & type tanks	-	more tanks system & non- system tanks	all

13. Workplan of the Bogor Research Institute for Food Crops

Bogor Research Institute for Food Crops
Jalan Cimanggu no. 3A
Bogor
West Java
Indonesia

The BORIF-SARP team is composed of:¹

Dr. A. Karim Makarim	Plant Physiologist (Team leader)
Dr. A. Hidayat	Plant Physiologist
Ir. Sutoro, MS	Agronomist
Dr. S. Tirtowirjono	Plant Breeder

¹ At the time of Planning Workshop, March 1992.

Background

In Indonesia rice and soybean are grown under diverse environmental conditions. The main typologies of agriculture areas in Indonesia are as follows: irrigated, rainfed lowland, upland and tidal swamp. The crop yields also vary from one location to another, and even within one location but different seasons due to genetic and environment interaction. This situation causes yield instability.

Simulation modelling has its potential to determine the yield potentials of rice and soybean varieties or lines under different agroclimatic zones. Therefore, it can help the breeder to develop varieties or lines suited for each zone. However, the L1D module needs to be evaluated with respect to its suitability under different environmental conditions.

Agro-ecological zonation in Indonesia is required since we meet a more and more intensive development of agriculture that needs optimum management and inputs. It is well known that land productivity varies mostly due to variations in soil type and/ or weather conditions. The availability of water in a year around in the land often determines cropping pattern or cropping intensity. The best planting time of rice and soybean in one rotation, and the varieties used are dependent on water availability. Therefore, water availability needs to be identified and classified in each region. However, the L2SS module needs to be evaluated for its suitability under diverse environments.

Nitrogen fertilizer efficiency for rice under lowland conditions is very low. Some of nitrogen applied is lost by leaching, run off, or taken up by soil micro-organism. The efficiency also depends on soil type and plant variety. The dynamic of nitrogen within a soil-plant system is still not well understood. Modelling is expected to help understanding the mechanism. Improvement, development and validation of L3C module for nitrogen dynamic are required.

Impact of stemborer on rice yield in Indonesia is great and unpredictable. The relationship between population and the degree of damage on rice plants need to be formulated. Simulation is expected to be able to predict population and economic threshold. However, the module L1Q including tillering needs to be evaluated for its suitability under different environments.

Objectives

- To determine the yield gap and the limiting factors of different climatic conditions.
- To improve efficiency of varietal yield trials.
- To determine the suitability of soybean and rice varieties to be grown in different locations.
- To evaluate adaptability and suitability of soybean varieties under rice based cropping systems at different agro-ecological zones.
- To clarify nitrogen behavior in lowland systems.
- To clarify P behavior in upland systems.
- To evaluate the suitability of the L3C model.

- To determine economic threshold of stemborer.

Approach

1. Model evaluation

The modules L1D, L2SS, and L3C will be evaluated with respect to their suitability under different conditions. The simulation results will be compared with the actual results of the experiment. Several parameters (plant and soil) measured from field trials will be incorporated into the models. If the results of the simulation and actual agree well, then the model could be used for other situations. If the simulation results do not agree with the actual ones, then the model requires improvement.

2. Model application

If the model is satisfying, then the model could be applied to predict the characteristics of the other areas. At this stage the model will be further tested. By using required parameters of weather, crop, and soil of various areas, the productivity, water and nutrient status could be simulated. The results could be used as guidance to select the area(s) for conducting research. If the results of simulation and experimentation again agree well, then the model has a power for prediction. Application of the model will become very useful. The advantage of simulation techniques compared to experimentation or observation is that models are faster, cheaper, and flexible. However, the disadvantage is the results sometime differ with the reality.

13.1 Agro-ecosystems

13.1.1 Agro-ecological zonation based on water balance

Study will utilize weather data of several locations in Java, Indonesia for a minimum of two years. The data needed are mainly rainfall, air temperatures (maximum and minimum), air humidity, wind speed, evaporation, and radiation. Soil characteristic data will also be collected mainly for some physical properties such as texture, soil water-characteristic curves, soil layers, infiltration rate, depth of water table etc.

A simulation study will be conducted using the MACROS model (Sawah/L2SS modules) by which water availability in soils could be calculated for each day. The sites, then, will be classified based on water availability characteristics such as long flood, long wet, medium moist, and long dry. This study will be continued by incorporating rice and soybean data, to find out the best cropping pattern in those in one year. The simulated and actual data of crops will be compared to evaluate the suitability of the model.

13.2 Potential production

The LID module from the model MACROS (Penning de Vries et al., 1989), a summary model in the computer language CSMP (Continuous Simulation Modelling Program) for an IBM-AT computer will be used in this simulation study.

Experiments will be conducted at several locations that differ in altitude to evaluate the model. Five varieties/lines of rice and soybean will be planted in a randomized complete block arrangement with 4 replications. Distance of planting for rice will be 20 cm × 20 cm, and for soybean will be 20 cm × 30 cm. One three week old seedling of rice will be planted per hill, whereas two seeds of soybean will be planted per hill. Fertilizers will be given at the rate of 150-75-75 kg ha⁻¹ N-P-K for rice and 75-75-75 for soybean.

Data to be collected from these experiments are:

- weight of seedling at transplanting (for rice) and weight of seeds at planting (for soybean);
- dry matter production; samples will be collected every 10 days after (trans)planting, 3 hills per sample;
- days to flowering;
- days to maturity;
- maximum number of tillers per hill (for rice);
- number of panicles per hill (for rice);
- number of pods per hill (for soybean);
- grain yield.

Based on the data collected from the field experiment, the following parameters in LID model will then be adjusted accordingly : WLVI, WSTI, DS, ALV, WLV, SLC, CALVT, CASTT, CASST, DRCV, DRCR, and DATEB. To simulate the grain yield at different transplanting dates, the model will be run at DATEB=1 and every consecutive 10 days.

13.3 Crop and soil management

13.3.1 Dynamics of N in lowland conditions

The field experiments will be conducted at Muara (a Latosol) and Serang (a Hydromorphic soil) using 3 varieties of rice and 3 rates of N (0, 75, and 150 kg N/ha). Experimental design will follow a Randomized Complete Block with 3 replications.

All treatments will receive the same amount of P and K, namely 90 kg P₂O₅ and 90 kg K₂O/ha.

Data collected are as follows:

- total fresh and dry weight of roots;
- plant height and tiller number;
- stem weight;
- leaf weight;
- leaf area;
- panicle weight;
- grain weight;
- nitrogen content of plant parts (stems, roots, leaves, panicle, and grain).

The simulated results using the L3C module will be compared with the experimental results.

13.3.2 Dynamics of P in upland condition

The field experiments will be conducted at Jasinga (a Red yellow Podsollic) and Bogor (a Latosol). Three varieties of soybean and 5 levels of P (0, 30, 60, 90, and 120 kg P₂O₅/ha) will be tested. The treatments will be arranged according to a Randomize Complete Block design with three replications.

Data observed are as follows:

- fractionation of soil P at intervals of 10 days started from planting;
- P content of plant parts (roots, stem, leaves, and pods during plant growth (at 10 days interval);
- weight of plant parts are measured at 10 days interval up to harvest.

The simulated results (using L1D+L2C+L4C) will be compared with the observation results from the experiments.

13.4 Crop protection

13.4.1 Simulation of stemborer damage

The degree of stemborer damage of rice plants will be correlated with the insect population in the field and rice yield. About twenty locations which are spread upon rice center areas of Java will be chosen. The other plant parameters measured are dry matter weight, number of tillers (health and infected), leaf area and grain yield. Fertilizer uses, and weather data will be recorded.

Expected Output (Whole team)

1. Improved L1D, L2C, L2SS, L3C, and L4C simulation models.
2. Understanding the mechanism within rice and soybean varieties related to high yield level.
3. Understanding the dynamics of N in lowland soil and within rice plant.
4. Database of climate, soil characteristics, and plant parameters of several varieties related to yield levels.
5. Maps of varietal zonation of Java.
6. Map of soil water availability of rainfed for certain regions of Java.
7. Understanding of the dynamic of P in upland and within soybean plant.
8. Economic threshold for stemborer control.

Workplan (BORIF)**

Research topic	91	92	93	94	95
I. Potential production					
a. rice	*	*	*		
b. soybean	*	*	*		
II. Agro-ecological zonation					
a. water balance	*	*	*	*	
b. rice-soybean varietal zonation	*	*	*	*	
III. Dynamics of N and P					
a. N in lowland	*	*	*		
b. P in upland	*	*	*		

** The five year plan has already been approved. However, within each year it will be re-evaluated again based on budget availability.

14. Workplan of the Sukamandi Research Institute for Food Crops

Sukamandi Research Institute for Food Crops
Jalan Raya No. 9
Sukamandi
Subang 41256
West Java
Indonesia

The SURIF-SARP Simulation Team is composed of:¹

Dr. A.M. Fagi	Team Supervisor
Dr. A. Andang Daradjat	Team Leader
Ir. R. Tejasarwana, MS	
Ir. A. Rahayu	
Ir. Zadri Hamzah	
Ir. Irmansya Rusli	
Ir. Yunizar	

¹ At the time of Planning Workshop, March 1992.

Background

Rice in Java is planted in diverse environmental conditions. Different agroclimatic and soil conditions, and cultural practices cause variation in rice yield. Better understanding of cultivars x environment interaction will help developing methods to narrow the yield gap between actual and potential yields.

Agro-ecological zonation in Indonesia is becoming important since more and more intensive development of agriculture that need an optimum management, and right places. It is a well known that land productivity varied mostly due to variations in soil type and/or weather condition. Uptake of nutrient by the plant is governed by the availability of the element in the soil. Since rice in Java is grown on a variety of soil types, specific suitable technologies to increase nutrient use efficiency for each particular agro-ecosystem have to be determine.

Objectives

Immediate: To characterize growth and development of rice varieties as effected by weather fluctuations.

To determine yield limiting factors for rice grown in the north coastal region of west Java.

To improve nitrogen use efficiency in lowland ecosystems.

To improve efficiency of varietal yield trials.

Long-term: Varietal zonation

14.1 Agro-ecosystems

14.1.1 Characterization and delineation of rice crop potential in irrigated and rainfed lowland ecosystems

Introduction

In Java, rice is grown throughout the year with the sowing season in April-May-June (dry season) and in October-November-December (wet season) depending mainly on the availability of irrigation water and rains. The northern coastal part of West Java is one of the centres for rice production, contributing 9.5% of the national rice production of Indonesia. Unfortunately, in this region, rice production varies significantly between the two seasons. Different agroclimatic, soil conditions, cultural practices, and varieties cause the variability in yield and yield potential. Climatic condition will determine yield potential of rice varieties if there is no other limiting factors. In order to determine the impact of climate

change on the rice productivity and to determine the yield potential of several rice varieties in the northern coastal region of West Java, the following activities will be done within the seasons.

Approaches

Field experiments

A field experiment will be conducted in Jatiluhur Irrigation Authority Area to determine several crop parameters such as : phenological development, leaf area development, source-sink relationship during grain filling period. Three varieties (late, medium, early maturing type) will be planted at 20×20 cm with 1 seedling hill-1. Fertilizer will be applied at the rate of 180 kg N ha^{-1} , $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$, and $50 \text{ kg K}_2\text{O ha}^{-1}$ as urea, triple superphosphate, and potassium chloride, respectively. $\frac{1}{4}$ of N fertilizer and all dosages of P and K fertilizer will be applied as basal treatments. Another $\frac{1}{4}$ of N fertilizer will be applied at tillering, panicle initiation, and 10% flowering stages, receptively. Insecticides will be used for pest control and weeds will be controlled by hand-weeding. Sampling for growth analysis will be done at 10 days interval after transplanting up to harvesting. Measurement will be done by gently pulling out 10 randomly selected hills per plot, and wash the roots to remove soil. These plants will then be separated into leaf, sheath, root and panicle, and dried in an oven maintained at 70°C for at least one week, and after that the dry weight of each organ will be measured. The leaf development will be determined by measuring leaf area and leaf dry weight of every plant sample. For determining yield components, duration and rate of grain filling panicles will be collected at intervals of 5 days starting at the first day of panicle emergence up to harvest; separated into filled and unfilled spikelets. Total dry weight of each sample is determined after drying for at least one week in an oven. Soil samples will be taken from each site before experiments carried out. Weather data at each location will be monitored daily. These data will be used to simulate the potential production of different varieties at different locations.

Simulation modelling

The L1D and L2C modules of the Macros model will be used as the basic modules. Some values in the programs will be modified accordingly with respect to the parameters obtained from different rice varieties used, climatic conditions, and soil characteristics of the locations.

14.2 Crop and soil management

14.2.1 Simulation of nitrogen requirement and nitrogen recovery of several rice cultivars grown under the northern coastal region of West Java environments

Introduction

One of the important factors affecting rice yield is the availability of nitrogen. This mainly depends upon its presence in the soil and on the extent and density of the plant root system (Van Keulen et al., 1975). However rice is a crop which uses nitrogen fertilizer inefficiently (Mitsui, 1954, De Datta et al., 1968). Fertilizer applied to lowland rice is often inefficiently used by the plant because of irregular moisture supply and improper application method and timing (De Datta, et al., 1988). Yields of rice grown in different soil environments vary. However, this variation depends on many factors that cannot be easily separated. Therefore in order to make better use of natural resources and to refine fertilizer recommendation to be suited at a specific location it is necessary to find out the nitrogen requirement and nitrogen recovery of a certain rice cultivar grown in different soil types. To clarify the relationship between soil nutrient status and yield potential the following activities will be carried out.

Field experiments

The field experiment for determination of the optimum application rate of nitrogen fertilizer will be conducted in three locations having three different irrigation schedule within Jatiluhur Irrigation Systems. Three rice cultivars belonging to late, medium, and early maturing variety will be planted at a distance of 20×20 cm with 1 seedling hill-1. Five levels of nitrogen (0, 45, 90, 135, and 180 kg N ha^{-1}) will be applied in combination with 4 times of application (Transplanting, Maximum Tillering, Panicle Initiation, and Flowering). Phosphate and potassium fertilizer will be applied as basal treatment at the rates of $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$, and $30 \text{ kg K}_2\text{O ha}^{-1}$, respectively. Insecticides will be used for pest control and weeds will be controlled by hand-weeding. Sampling for growth analysis and plant organ nitrogen content will be done at transplanting, maximum tillering, panicle initiation, flowering, and maturing stages of the crops. Measurement will be done by pulling gently 10 randomly selected hills per plot, and by washing the roots to remove soil. These plants will then be separated into leaf, sheath, root and panicle, and dried in an oven maintained at 70°C for at least one week. The dry weight and nitrogen content of each organ will be measured. The leaf development will be determined by measuring leaf area and leaf dry weight of every plant sample. For determining yield components, duration and rate of grain filling, panicles will be collected at intervals starting at first day of

panicles emergence up to harvest and will be separated into filled and unfilled spikelets. Total dry weight of each sample will be determined after drying them for at least one week in an oven. Soil samples will be taken from each site before experiments carried out. Weather data at each location will be monitored daily. These data will then be used to simulate the potential production of different varieties at different locations.

Simulation modelling

The L1D + N, and L2C + N modules of the Macros model will be used as the basic modules. Some values in the programs will be modified accordingly with respect to the parameters obtained from different rice varieties used, climatic conditions, and soil characteristics of the locations.

14.3 Crop protection

14.3.1 Simulating the effect of stem borer infestation on yield reduction

Introduction

Stemborers are a major pest in many rice growing areas throughout South and Southeast Asia. There are six species of stemborers that attack the rice plant at any stage from seedling to maturity. One of them is rice white stemborer *S. innotata* (Walker) which destroyed millions hectares of rice crops in West Java in 1989/90 wet season. Damage by the larvae results in dead tillers or 'dead hearts' when inflicted at the vegetative stage and in empty grains or 'white heads' at the reproductive stage. Since the larvae live inside the stem, the presence of the insect is only detected when damage becomes visible. The relation between stemborer infestation level and yield reduction depends also on the age of the crop at the time of infestation. Such complex interactions are difficult to analyze with field experiments. This make the control of stemborer difficult. The impact of such interactions may also be studied by computer simulation using a physiological rice model. Simulation is based on the assumption that the state of an ecosystem at any particular time can be expressed quantitatively and that changes in the ecosystem can be described mathematically. Simulation modelling can be used as a tool for decision support in pest management programs. To clarify the relationship between the degree of stem borer infestation and yield losses the following activities will be done:

Approaches

Field experiment

A field experiment will be conducted using several cultivars having different maturity types. Effect of infestation will be mimiced by larvae inoculation at the tillering, panicle initiation, and flowering stages. Total tillers, deadhearts, and whiteheads will be observed weekly right after inoculation. These data will be used as input for the simulation model.

Simulation modelling

The LIQ TIL modules will be used to quantify relationships between different levels and timing of infestation and grain yield. Some values in the programs will be modified accordingly with respect to the parameters obtained from the field experiment or from existing infected rice field areas. In order to account shading effect into the model the photosynthesis subroutine SUPHOL (Penning de Vries et al., 1989) will be used. The canopy will be divided into two equal horizontal layers, with a leaf angle distribution depending on data collected from the fields.

Expected output

1. Data base on climate, soil characteristics, and plant parameters of several varieties.
2. Understanding the dynamics of N in lowland soil and within rice plant.
3. Information on the yield potential of several rice cultivars grown at different planting dates under irrigated and rainfed lowland rice ecosystems.
4. A dynamic economic threshold for stemborer control.

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15. Workplan of the Crop Experiment Station

Rural Development Administration
209 Seodundong
Suweon
South Korea

The CES-SARP Simulation Team is composed of:¹

Dr. Yun-Jin Oh	Head of Rice Production Division (Team supervisor)
Dr. Moon-Hee Lee	Rice Production Division (Team leader)
Dr. Jin-Chul Shin	Rice Production Division
Dr. Chul-Won Lee	Agronomist
Dr. Joo-Yeul Lee	Agronomist

¹ At the time of Planning Workshop, March 1992.

Background

Korea is self-supporting as far as rice is concerned. It is the most important crop for farmers' income and economic development. In 1990, 5.5 million M/T of milled rice was produced from 1.2 million ha of paddy rice fields. However, Korea has many unfavorable conditions for increasing rice production such as climate limitations, low soil fertility, socio-economic constraints, etc. The effect of global climate change on rice production has recently become another important research topic.

The problems for increasing rice production in Korea are :

Climate

- limited rice growing season : April to October;
- cold damage in early and late cultivation, and in mountainous areas causing delay of growth rate, poor grain filling.

Socio - economic situation

- farm population : 15.2%;
- poor farm labour quality : women, mostly elderly people;
- high production cost: replacement from hand transplanting to machine transplanting;
- and finally direct seeding.

Low fertilizer efficiency

- sandy soils occupy 30% of agricultural land;
- low cation exchange capacity : 8-12 me/100g.

Global climate change

- global climate change is expected to be an important factor for rice production in the future.

Objectives

To solve these problems, existing datasets will be analyzed and integrated with simulation models. Experiments will be conducted to develop and evaluate models. More specific the objectives are:

- To develop the optimum cultural practices under different climatic conditions: planting time and variety.
- To find the optimum seeding time and rate in direct seeding of rice in dry and wet soil environments.
- To find the optimum time of fertilizer application under different climatic conditions.
- To increase the fertilizer efficiency in different soil environments.
- To quantify the impact of global climate change for 2020 on rice production.

Workplan

1992-1993:

1. Partitioning of assimilates and effect of transplanting shock under extreme temperature conditions: duration, effect on growth, effect on phenological development.
2. Fertilizer uptake under different soil and temperature conditions.
3. Emergence rate of seedlings under different temperatures for direct seeded rice.
4. Impact of global climate change on rice production (EPA/IRRI).

1994-1995:

1. Photosynthesis and respiration of different varieties and temperature conditions.
2. Rooting activity under different temperature regimes in transplanted and direct seeded rice.
3. Fertilizer dynamics in different soil types and weather conditions.
4. Determination of fertilizer application methods.
5. Application of the model by extension workers.

15.1 Potential production

15.1.1 Simulation of Potential Production of Rice under different temperature conditions.

(Jin-Chul Shin, Moon-Hee Lee and Jea-Kyu Kim)

Background

Low temperature is the main constraint to increase the yield potential of rice for early and late transplanting in Korea. In the high mountainous areas, it can be a problem at any transplanting date. Improved cultural practices, therefore, need to increase yield potential under low temperature conditions. Problems are:

1. Delay of growth : early transplanting and mountainous areas:
 - Low photosynthetic activity.
 - Transplanting shock and low rate of N uptake: decreased tiller numbers, delay of development rate.
 - Partitioning of assimilates.
2. Poor grain filling
 - High temperature: short maturing variety in early transplanting.
 - Low temperature: late transplanting and mountainous areas.

Objectives

To find out the optimum cultural practices such as planting time, variety, fertilization and planting density, for increasing yield potential under low temperature conditions.

Approaches

1. Model : L1Q with tiller and weather data.
2. Data collection and phytotron experiment (at various temperatures and for different varieties) for model development (1992):
 - photosynthesis, respiration (pot experiment);
 - transplanting shock (duration);
 - leaf development and dying (number, leaf area);
 - partitioning carbohydrate (before and after heading);
 - grain filling duration and rate;
 - panicle exertion.
3. Develop the simulation model structure (1992-1994)
 - parameters and functions.
4. Field experiment for develop and evaluation of model (1993-1994)
 - variety : japonica type;
 - locations : plain and mountainous area;
 - date of transplanting : early, optimum and late.
5. Evaluation of model (1992-1996)
 - partitioning of carbohydrate;
 - development rate at different sites.

Expected output

1. Optimum transplanting date in different regions.
2. Selection and suggestions to breeders of the ideal type of rice variety under low temperature conditions.

15.1.2 Simulation of potential production of rice in direct seeding cultivation

(Moon-Hee Lee, Jin-Chul Shin and Yun-Jin Oh)

Background

At present direct seeding cultivation of rice is becoming more interesting as it contributes to labor saving and hence in cost reduction for rice in future strategies of rice cultivation. Direct seeding cultivation causes problems for the farmers due to cold injuries during

emergence, lower emergence rate in submerged conditions, difficult weed control and lodging after flowering and maturity.

Information about potential yield of direct seeding rice cultivation will be obtained through:

1. literature review;
2. quantification of the growth characteristics;
3. comparison of agronomic factors with transplanted rice.

Objectives

- To identify ideal type varieties for direct seeding;
- To determine the optimum seeding date and rate in relate to the emergence rate for increasing yield potential in direct seeding.

Approaches

1. Model : L1Q with tiller and weather area
2. Data collection: agronomic characteristics of direct seeding rice from previous experiment. (1992-1994)
3. Modification of model : function and parameters related to the phenological response under the actual climatic conditions. (1993-1995)
4. Evaluation of model : comparing simulated and observed data (if needed back to 3 and modification). (1994-1995)
5. Application : to determine the potential production in the direct seeding cultivation. (1995-1996)

Expected output

1. Establish the optimum cultural practices of direct seeding.
2. Selection and suggestion to breeders on ideal types of rice variety for direct seeding.

15.1.3 Modelling the Impact of Global Climate Change on Production of Rice Crop

(Moon-Hee Lee, Jin-Chul Shin and Yun-Jin Oh)

Background

Global climate change is one factor affecting the rice production during the next decades. Between 1990 and 2020 CO₂ concentrations will increase by more than 100 ppm and temperature by more than 1.5°C.

Objectives

1. Quantify the impact of climate changes for 2020 on rice production.
2. To determine the adjustment needed in physiological and morphological characteristics of rice to benefit optimally from the climate changes:
 - development of ideal type variety;
 - cropping system.

Workplan

1. Research structure
 - EPA / IIRI { Korea (CES): Team leader
 - Japan: Japan region
 - Malaysia: Malaysia, Indonesia
 - India: India, Bangladesh, Srilanka
 - China: China
2. Model development (1992):
 - model: MACROS (L1Q. CSM);
 - data collection : 10 years weather and crop data.
3. Model validation (1992):
 - Identify experiments, evaluation and dissemination.
4. Run the model and probability (1993):
 - weather data scenarios for 2020;
 - approximation impact climate change on rice production.
5. Linkage with GIS (1993).
6. Final model and sensitivity analysis (1993).
7. Mapping zones (1994).
8. Final workshop and report (1994).

Expected output

1. Define the futures improved rice production.
2. Estimation of rice productivity and production for 2020.
3. Identify new types of rice varieties.
4. Establishment of cultural practices of rice and cropping systems for 2020.

15.2 Crop and soil management

15.2.1 Nitrogen Dynamics in Paddy Soil in Relation to Root Growth in Rice

(Jin-Chul Shin and Moon-Hee Lee)

Background

1. The efficiency of N application in Korea is 30-40%.
2. Production cost increase as a result of excessive and inefficient application of N.
3. N-demand of the rice crop varies depending on development stage.
4. Excessive N-uptake leads to lodging and diseases.
5. Contamination of water and air by excessive application of N should be prevented.

Objectives

1. To increase the N efficiency in different soil and climate environments.
2. To identify the N demand and uptake in relation to growth stage in order to increase yield potential of rice.
3. To get a practical model to reduce N losses in paddy soil.

Approaches

1. Collect data from previous studies (1990-1992):
 - N movement in soil;
 - N uptake by the crop.
2. Conduct an experiment for N dynamics in soil relating to root growth (1990-1993):
 - N levels;
 - planting densities;
 - different rooting patterns.
3. Content of observations (1990-1993):
 - N concentration in soil layer;
 - root and shoot growth;
 - rooting pattern.
4. Develop the model to predict nitrogen dynamics and root development (1993-1994).
5. Model evaluation (1994-1995).

Expected output

1. Relate N efficiency to soil type, weather condition and rice cultivars.
2. Apply the model to determine best N application method: optimum rates and timing.
3. Advise on N application to achieve target yields.
4. Apply the results in extension work.

16. Workplan of the Universiti Pertanian Malaysia and the Malaysia Agricultural Research Development Institute

Universiti Pertanian Malaysia
43400 Serdang
Selangor
Malaysia

Malaysia Agricultural Research Development Institute
P. O. Box 12301
50774 Kuala Lumpur
Malaysia

The UPM-MARDI SARP Simulation Team is composed of:¹

Dr. Wan Sulaiman wan Harun	Soil Scientist (Team supervisor)
Dr. Surjit Singh	Agronomist (Team Leader)
Dr. A. Rajan	Agronomy (UPM)
Dr. Yusuf Ibrahim	Plant Protectionist (UPM)
Dr. Md.N. Hamid	Entomologist (MARDI)
Dr. Ahmad Selamat	Basic Research (MARDI)

¹ At the time of Planning Workshop, March 1992.

16.1 Agro-ecosystems

16.1.1 Agro-ecological Zoning

(Wan Sulaiman, Anuar Abd. Rahim, Jamal Talib, Leong Chee Onn, Shafei and Md. Sabtu)

For corn in Peninsular Malaysia

Workplan

Data collection: Aug. 1992 - Dec. 1993

Data processing/analysis: Jan.-June 1994

Final report: June 1995

16.1.2 Optimization of water use

(Wan Sulaiman, Ahmad Selamat and Surjit)

1. Monitoring yield loss due to water shortage.
2. Consider how to adjust models to sub-optimal production situations.
3. Use of hydrological model to allocate water across a command area/irrigation system.
4. Quantify effect of water use optimized systems on yield.

Workplan

1. Experimental: Aug. - Dec. 1992; March - June 1993; Aug. - Dec. 1993.
2. Model development/data processing: Feb. 1993 - June 1994.
3. Simulation analysis/Validation of hydrological model/Quantification: April-Dec. 1994.
4. Final report: June 1995.

16.2 Potential production

16.2.1 Process Research and Model development

(Surjit Singh, Wan Sulaiman, Ahmad Selamat, Yusuf Ibrahim and A. Rajan)

1. Impact of climate change on rice production.
2. Phenological development and leaf area development in direct seeded irrigated rice.
3. Photosynthesis/ Respiration in local cultivars.
4. Role of Nitrogen in grain filling and phenological development.

Work plan

1. - Model develop./improvement: March - Aug. 1992
 - Collection of weather/crop data (Malaysia, Indonesia, Philippines): Aug.-Sept. 1992
 - Model adjustment/Distribution to Teams: Dec. 1992
 - Simulation: Effects of temp. & CO₂ at test sites -Dec. 1992 - Feb. 1993
 - Simulation: Effects of temp. & CO₂ at all selected locations - March - June 1993
 - Simulation re-runs Prob. Analysis July-Dec. 1993
 - Final report: Dec. 1993 - Feb. 1994
2. - Experimental - Aug. 1992 -Dec. 1993
 - Model develop./improvement- July 1993 -June 1994
 - Final report: Dec. 1994
3. - Experimental: Aug. 1992 - Dec. 1993
 - Simulations: June 1993 - July 1994
 - Final report: Dec. 1994
4. - Experimental -Aug. 1992 - Dec. 1993
 - Model develop./improvement- July 1993 - June 1994
 - Final report: Dec. 1994

16.3 Crop and soil management

16.3.1 Water limited production

(Wan Sulaiman and Ahmad Selamat)

- Effect of water stress on crop development and production.

Work plan

- Experimental: Aug. 1992 - Dec. 1994
- Model develop./improvement: July 1993 - June 1994
- Final report: Dec. 1994

16.4 Crop protection

16.4.1 Insects

(Yusof Ibrahim and Md.N. Hamid)

1. Stem-borer
2. Leaf-folder

3. Malaysian Black Bug
- Quantification of effects of pest on damage mechanisms
- Model development/improvement

Workplan

- July 1992 - October 1993 (Glasshouse)
- Feb. 1994 - June 1994 (Field)
- Final report: Dec. 1994

16.4.2 Weeds

(A. Rajan, Surjit and Yusof)

Applied Research: (Weed species: *E. crus-galli*)

1. Competition on assimilate partitioning.
2. Relative emergence time on crop development rates.

Workplan

1. - July 1992 - October 1992 (Glasshouse)
 - Feb. 1993 - June 1993 (Field)
 - Final report: Dec. 1993
2. - July 1993 - October 1993 (Glasshouse)
 - Feb. 1994 - June 1994 (Field)
 - Final report: Dec. 1994

17. Workplans of the Institute for Environmental Studies and Management (IESAM)

University of the Philippines at Los Banos (UPLB)
College
Laguna
The Philippines

The IESAM-UPLB Simulation Team is composed of:¹

Dr. Enrique P. Pacardo	Director (Team supervisor)
Dr. Felino P. Lansigan	Statistician, Hydrologist (Team leader)
Ms. Jesusita L. Orno	Soils Scientist
Dr. Maria M. Paje	Crop Physiologist
Dr. Arnold L. Garcia	Agronomist
Dr. Benjamin A.C. Legaspi	Crop Ecologist
Ms. Damasa M. Macandog	Crop Physiologist/Soil Scientist
Mr. Charito P. Medina	Entomologist

¹ At the time of Planning Workshop, March 1992.

17.1 Agro-ecosystems

17.1.1 Evaluation of the Effects of Climatic Variations and Change on Temporal and Spatial Variabilities in Rice Crop Yields in the Philippines

(F.P. Lansigan and J.L. Orno)

Objectives

1. To develop useful quantitative estimates of variations in rice crop production caused by climatic factors specifically precipitation and temperature as well as carbon dioxide concentration.
2. To evaluate weather effects on crop production in the Philippines in the terms of crop yield exceedance probabilities for agro-ecological characterization and zoning.

Expected Outputs

1. Assessment of standard analytical procedures for evaluating yield variability and stability of crop production.
2. Regional maps of the Philippines with isolines of equal yield variability or probability of exceedance for specific yields.

17.1.2 Delineation of Potential Cropping Patterns in the Rainfed Lowland and Upland Ecosystems in Relation to Some Climatic and Soil Variables

(A.G. Garcia, F.P. Lansigan and J.L. Orno)

Objectives

1. To develop and evaluate a user-friendly model that could delineate potential cropping patterns or crop sequences in relation to some environmental factors (e.g. rainfall, solar radiation, temperature, evapotranspiration) and soil type in a rainfed lowland and upland ecosystems.

Expected Outputs

1. A user-friendly model which can estimate potential crop productivities.
2. A decision-making tool that can delineate promising cropping pattern for specific locations within an agro-ecosystem.

17.2 Potential production

17.2.1 Effects of climate change on rice growth and rice production in the Philippines

(F.P. Lansigan, J.L. Orno and M.M. Paje)

Objectives

1. To assess risk and uncertainty in rice crop yields due to anticipated climate change (i.e. increased temperature, carbon dioxide concentration and precipitation).
2. To determine the effect of anticipated climate change on rice crop growing periods under different climatic types and agro-ecosystems.

Expected Outputs

1. Quantitative estimates of rice crop yields and yield variabilities for representative locations under anticipated climate change conditions.
2. Quantification of probable effects of climate change on the 'optimal' rice growing periods in representative sites.

17.3 Crop and soil management

17.3.1 Optimization of water and nitrogen utilization in a tomato-after-rice cropping system

(M.M. Paje and J.L. Orno)

Objectives

1. To determine the effect of varying date of planting tomato from time of harvesting rice on water availability in the soil profile.
2. To measure water use and water use efficiency of tomato-after-rice cropping system.
3. To determine the effects of gradually developing water stress on yield formation.
4. To determine the influence of a continuously depleting water supply on nitrogen uptake and utilization of tomato.

Expected Outputs

1. Basic information on optimizing water availability and use by adjusting planting date of tomato from date of harvesting rice.
2. Management recommendations as to what form, how much and when to apply the N-fertilizer under a condition of continuously depleting water supply.
3. Effects on yield and sink formation by gradually developing water stress.

Promotion of Systems Analysis and Simulation in Agricultural Research and Development

The UPLB-SARP Team plans to promote the use of:

Systems analysis and simulation (SAS) approach as a tool in agricultural research through the following activities:

1. Enhancing linkages with the Philippine Department of Agriculture (DA) researchers and planners on the use of SAS approach. UPLB-SARP Team members (F.P. Lansigan and A.G. Garcia) have already established close contacts and working relationships with the DA agencies on specific research problems or concerns.
 - a. Bureau of Agricultural Research (BAR) - use of SAS approach in optimizing conduct of on-farm trials (OFTs) on specific cropping systems or agricultural technologies e.g. fertilizer rate experiments, varietal trials; extrapolation of recommendation domains for specific technology.
 - b. Philippine Rice Research Institute (PhilRice) - use of SAS in rice-based cropping systems research; agro-ecological zoning of the possible and existing rice growing areas with respect to rice yield potentials in relation to climate, soils and other environmental factors.
 - c. Bureau of Agricultural Statistics (BAS) - adaption of an ecophysiological-based crop simulation model for rice crop yield forecasting.
2. Institution of graduate course on systems analysis and simulation at UPLB.

The use of systems analysis and simulation as a research tool in agro-ecosystem research and environmental studies has long been recognized in the University. A graduate level course on systems analysis which has been initiated and being taught by the Team Leader since 1985 involves systems modelling and simulation as major topics. At present, there is a great demand within UPLB for a graduate course on Systems Modelling and Simulation in Agro-ecosystem Research which will be initiated by the Team.
3. Seminar Series on Systems Analysis and Simulation

As a strategy to promote SAS approach and to provide a forum for exchange of professional experiences on applications of modelling and simulation, a UPLB Seminar

Series on SAS will be launched starting first semester of school year 1992-93. The seminar series is a joint undertaking of IESAM and IMSP.

The seminar series will feature research outputs of SARP modelers, IBSNAT collaborators and other 'free-lance' modelers within the Los Banos science community.

4. Workshop on SAS in Agro-ecosystem Research and Development in the Philippines. The UPLB Team also plans to initiate and co-sponsor regular research workshops or meetings among Filipino scientists-modelers from UPLB, PCARRD, DA and some state colleges and universities (SCUs) in the regions to discuss, formulate and plan strategies for collaborative research with the use of SAS approach. Regular 3-day workshops (with at most 20 participants) will be held once a year beginning middle part of 1992.

18. Workplan of the Khon Kaen University

Khon Kaen University
40002 Khon Kaen
Thailand

The KKU-SARP Simulation Team is composed of:¹

Dr. Terd Charoenwatana	Head, Rural Resource System Project (Team supervisor)
Dr. Manochai Keeratikasikorn	Entomologist (Team Leader)
Dr. Sirichai Kalayanarat	Horticulturist
Dr. Suwit Laohasiriwong	Agronomist
Dr. Krirk Pannangpetch	Agronomist
Dr. Nimitr Vorasoot	Agronomist
Dr. Viriya Limpinantana	Agronomist

¹ At the time of Planning Workshop, March 1992.

Background

Northeast Thailand covers an area of over 170,000 km², one third of the entire country, and is the poorest region of Thailand. The average annual rainfall is about 1000 mm of which 80% is received in the six months rainy season.

The uncertainty of rainfall is a major constraint to farming in the region. In general the weather can be divided into two seasons. The main part of the wet season is from May to October with the temperature ranging between 25°C to 34°C with a high humidity. The rainy season ends abruptly in November. The dry and cool season then follows with the temperature ranging between 17°C to 31°C from December to February. Temperature then increases considerably in March and April sometimes upto 42°C.

The Northeast is a plateau characterized by a rolling terrain that on average is between 100-200 m above sea level in elevation. Many different soil types occur in this region. They are loamy sands and sandy loams which have low fertility and low moisture holding capacity.

Glutinous rice is the main staple crop grown by most of the farmers for home consumption. One of the constraints for rice production is insect pests. Stemborer is considered to be the important pest in the Northeast. The farmers also grow other crops such as cassava, kenaf, grain legumes, vegetables, and other garden crops. They manage available resources in such a way that their risks are minimized and some returns will be obtained.

The KKU Rural Resource System Project at the Khon Kaen University has an objective to identify and test improved strategies and technology for national resource management and disseminate the promising ones to the farmers. With a simulation model, the KKU team could scientifically recommend the proper cropping systems in suitable environments.

Objectives

1. To use crop modelling as a tool to provide alternative options in rice based cropping systems in space and time to improve crop productivity.
2. To use crop modelling to provide crop loss assessment due to stemborer.
3. To further develop, modify, and apply crop modelling to suit the Northeast conditions.
4. To continue linkage and cooperation and share experience with other SARP member institutions.

Approach

Crop modelling will be used as a tool to accelerate the progress by conventional experimental approaches which are rather costly in terms of time and finance in various environmental conditions found in the northeast of Thailand.

Growth and yield of rice and some legumes will be simulated over time and space by using the environmental data from the GIS system based at the Rural Resource System

Project, Khon Kaen University together with crop data which have been adapted to certain extent for the local varieties.

The results will then be evaluated and validated accordingly to set up the most feasible cropping system for each land unit. The field experiments will then follow to validate these possible cropping patterns. Any necessary further model adaptation will then be carried out.

Workplan

	Rice	Peanut	Soybean
1992	1. Environmental effect on leaf N content 2. Stemborer	1. Potential production	1. Potential production
1993	1. Nutrients 2. Stemborer	1. Water balance	1. Water balance
1994	1. Model construction 2. Stemborer	1. Water balance	1. Water balance
1995	1. Application & validation	1. Application & validation	1. Application & validation

Expected Output

Simulation modelling should provide support for decision making.

The experience of research in modelling will be shared and integrated with researchers from other institutes.

18.1 Crop and soil management

18.1.1 Modelling the effect of nitrogen on growth and yield of rice (Kirk Pannangpetch and Viriya Limpinuntara)

Background

Crop production in the northeast of Thailand is primarily determined by soil moisture and nutrient availability. From the analyses of rainfall pattern and soil type, double cropping is possible in some rainfed areas especially those having shallow ground water. However because of strong soil heterogeneity at microscale, the process of technological transfer from

experimental results to farmer fields is difficult. Crop modelling can assist in defining land suitability classifications for crop production. Early application of a crop model in this aspect showed promising results, even though discrepancy between simulated and observed results was observed (Pannangpetch, 1991). One of the possible causes for this discrepancy could be attributed to the lack of crop model response to soil nutrient availability. In order to improve the model response, the relation of crop growth and yield to soil nitrogen availability will be investigated.

Objectives

1. To determine the relation between leaf nitrogen contents and leaf photosynthesis.
2. To determine crop nitrogen partitioning.
3. To determine the potential nitrogen uptake.
4. To determine the relation between actual nitrogen uptake and soil nitrogen availability.

Approaches

1992: Objective 1, and 2, and submodule development

1993: Objective 3, and 4, and submodule development

1994: Validation and refinement of the constructed submodule

Experiments will be conducted under glasshouse conditions at the faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand, during the rainy season.

Expected output

Better agreement between simulated and observed rice yields will be obtained and will enable the application of crop modelling for land suitability classification.

18.1.2. Modelling the effect of light and water on growth of soybean (N. Vorasoot)

Background

Soybean is one of the major important grain legumes that are widely grown in upland areas. It can be grown successfully under rainfed as well as under fully irrigated conditions in the North and Northeast regions of Thailand. It can be grown during the main growing season and also after rice growing season in paddy field. However, soybean production in Thailand still does not meet the demand. This may be due to use of low yielding cultivars,

improper cultural practices, lack of water for irrigation, low soil fertility, diseases and insect pests.

Simulation modelling, can be used to determine the yield potential of crops and yield constraints and therefore will be applied in this study.

Objectives

1. To determine yield of soybean under different light and soil water conditions.
2. To implement and test the use of simulation modelling for the improvement of soybean production in Thailand.

Approaches

The experiment will be conducted at the Research Farm of the Khon Kaen University. Two soybean cultivars, i.e. SJ.4 and KKU 1007 will be grown during the dry period, crop growth analysis will be taken once a week. Climatological data including intercepted radiation and soil moisture will be recorded throughout the growing season. Simulation of crop growth will be conducted using the L1D + L2C modules together with the L2SU module.

Expected output

A realistic model will be developed for the simulation of soybean production in Thailand.

18.1.3 Effect of different plant populations and different water regimes on soybean production

(S. Laohasiriwong)

Background

Soybean is an important crop for Thailand. The country needs about 900,000 tons /yr. At the moment only half of that amount is produced. Soybean is used as a dry season crop after rice. Traditionally the main growing area for soybean is in the north of Thailand. No more expansion of this area is possible, the north-east is now being explored for growth of soybean. In irrigated areas soybean can grow very well in the dry season. Some potential areas in the north-east are available if additional irrigation is applied. Additional irrigation water maybe provided with pumps of ground water is not too deep. In a later stage GIS-modelling will be used to explore suitable new areas for soybean.

Objectives

1. To determine yield of 3 soybean cultivars under different plant densities and soil-water conditions.
2. To investigate the response of 3 soybean cultivars with different growth periods.

Approach

Experiment will be conducted in three seasons (one experiment is ongoing): early rainy season, late rainy season and dry season. Two regimes will be used: well-watered and rainfed (care is taken that emergence is established especially for the dry season). In dry season some additional irrigation may be needed to avoid early dying of the crop. Amount of irrigation that is applied is measured and soil moisture content are measured as well. The SAHEL soil-water model will be used.

18.2 Crop protection

18.2.1 Simulation of population and yield loss of rice caused by stem-borers

(M. Keerati-Kasikorn and W. Mekwattanakarn)

Background

Stem-borers cause rice yield losses upto 50% in the off-season planting. However in the normal planting, the loss generally is only 10-20% . The larvae feed on the leaf tissues before they enter into the stem. They continue to feed inside the stem throughout their larval stage. This results in 'deadhearts' in the tillering stage and 'white heads' in the reproductive stage of the crop.

The yield loss relationship between a crop and its insect pest is influenced by several factors. These interactions are complex and difficult to analyze in the field. To overcome this problem, crop growth simulation modelling can be used.

Objectives

1. To establish a simulation model for the complex interactions between rice crop and stem-borers.
2. To determine the effect of stem-borers on crop growth and yield.
3. To make use of the model to improve insect pest management in rice cropping systems.

Approaches

The MACROS simulation modules L1D and TIL will be used to understand the mechanisms involved in the reduction of yield due to stemborers. The experiments will be conducted at the Khon Kaen Rice Research Station. Field data will be collected in 1992. The simulation results will be evaluated using the field data and the model will be refined for realistic results.

Expected output

Information on stemborer and rice interactions obtained through field experiments and simulation modelling will serve as a decision support system.

APPENDICES

Appendix 1. Participants and disciplines

Participants	1986	1988	1990	Total
Bangladesh	0	4	4	8
China	0	8	3	11
India	8	4	8	20
Indonesia	4	4	5	13
IRRI	4	0	4	8
Malaysia	4	0	2	6
Philippines	4	0	2	6
Sri Lanka	4	0	2	6
South Korea	0	4	0	4
Thailand	4	0	3	7
Total	32	24	33	89

Disciplines	1986	1988	1990	Total
Agronomy	8	4	5	17
Plant/crop physiology	3	6	4	13
Entomology	5	3	5	13
Plant breeding	2	4	2	8
Soil chemistry/Plant nutrition	3	4	1	8
Plant pathology	3	1	3	7
Soil physics	2	1	4	7
Statistics/Computer	3	-	3	6
(Micro)meteorology	2	1	1	4
Forestry	-	-	1	1
Irrigation/Water management	-	-	1	1
Food engineering/Aqua culture	-	-	1	1
Weed science	-	-	1	1
Horticulture	-	-	1	1
Nematology	1	-	-	1
Total	32	24	33	89

Appendix 2. Research topics and activities

Two basic components of systems research are analysis and integration. Some activities aim at the first of these components, i.e. generating process knowledge at the crop level, while other activities aim at applying insights in integrated form to help formulate research conclusions.

Process research activities in the project will include summarizing the results obtained earlier in the form of standardized simulation models, and making these available to all research teams for testing under different circumstances. Continued support will be given to data collection, parameterization, and model validation under specific constraints such as weather conditions, varietal characteristics, nutrients and water, and pests, diseases and weeds.

A main thrust of SARP-III will be to apply the obtained process knowledge in formulating recommendations of direct relevance, both directed at farming practice and at decision making at regional and national levels. Effective support to the NARCs in application requires identification of elements common to all teams. Summarizing the current research priorities as given by the various NARCs (this appendix) leads to the application fields listed in Section 2.3.1. This appendix presents the main issues in each of the four themes.

1. Agro-ecosystems

The theme 'Agro-ecosystems' serves as an umbrella for research output from the other themes. Agro-ecosystems comprise a higher integration level than crop or field studies in the other themes, and provides a starting point for studies on farm economics and regional zonation. For these reasons, applied research in 'agro-ecosystems' will be particularly emphasized.

Ongoing research for optimization of cropping systems by simulation will continue, e.g. on problems of establishment and yield stability of crops before or after rice. Important aspects are timing of the crop, crop selection, analysis of temporal variability due to weather, and risk analysis for inputs. These studies deal with problems at the farm or field scale.

This research can be applied relatively easily for zonation studies, for which there is much demand in NARCs. In SARP-III teams, will be provided with a simple Geographic Information System (GIS), which will be comprised of a data base / mapping software package. SARP will demonstrate how the combination of models plus GIS can be used:

- to make maps of environmental conditions, including soils and climate;
- to translate environmental conditions into production potentials for different crops, and present these on maps;
- to assess the impact of climate change on regional production;
- to plan land use at the regional level.

2. Potential production

Potential production is governed by the growth defining processes. These are affected by weather conditions (radiation, temperature) and crop varietal characteristics. Potential production estimates, either measured or calculated, are the starting point for yield gap analyses. They also provide basic information on the maximum return one may expect from farm inputs; and from larger scale interventions such as irrigation development and drainage.

Process research to improve potential production models will focus on dry matter partitioning and tiller formation. In addition, some teams have a special interest in grain filling in relation to temperature, and in plant characteristics favorable for low light conditions (light response curve; stem reserves).

Potential production models serve a purpose by setting reference levels for process research in themes 3 and 4, but are mainly used in applied research on a number of topics central to SARP-III:

- zonation at national and regional scales; this is one step in the identification of alternatives for land use (theme 1);
- optimization of cropping systems (theme 1);
- pre-release testing of new varieties;
- design of ideotype plants for given environments and cultural practices;
- studies on the effects of global climate changes on production.

Data collected in the IRRI-WMO Rice Weather Program are used extensively in this theme.

3. Crop and soil management

In the field of crop water supply, the crop's responses to shortage and excess of water will be studied. Responses will be described in terms of:

- root development (distribution; root length density);
- partitioning of carbon between root and shoot;
- water uptake vs. water availability at different development stages;
- effects on sink size (tiller number; grain number);
- effects on reserve accumulation;
- effects on grain filling.

Bulk water movement in the soil profile will not be studied, since it is felt that no more knowledge or model development is required to adequately describe soil water movement. The collection, organization, and interpretation - by simulation models - of relevant soil data, however, will remain an important activity, especially in the context of the GIS. See theme 1.

Crops studied in relation to water management will include rice (drought), wheat (drought; water logging), and pulses (drought, water logging).

Nutrient research will be concentrated on the study of nitrogen. The studies that started in phase II on uptake at given availability and given crop development stages will be intensified. The partitioning of nitrogen and carbon in the plant, in response to crop nitrogen level will continue to be an important aspect (root:shoot interactions). This includes effects on tiller and grain formation, and on leaf senescence as determined by nitrogen translocation.

Nitrogen uptake, one of the sink terms in the soil-nitrogen balance, will be studied in close relation with root distribution and activity. While, similarly to the case of soil water, no attempts will be made to further develop existing models of soil nitrogen dynamics, there is a need to assemble segments of models available elsewhere into a coherent framework. Many basic elements resulting from recent studies completed at IRRI will be taken into account in this effort.

Of the various crops in rice based systems, rice will receive major attention, although the current work of some groups on wheat and pulses will be encouraged. In the latter case, effects of drought and excess water on N fixation are important aspects.

Applied research in this theme will aim at the formulation of input-output relations that can be used for farm resource optimization under theme 1. Such formulations can be either in the form of metamodels derived from process models, or empirical functions.

Another application in agro-ecology of results from theme 3 is in risk analysis for rainfed systems, with respect to crop failure and nitrogen efficiency. Models of crop response to drought and nitrogen deficiency provide useful tools in yield gap analysis.

4. Crop protection

Reduction of yield losses due to pests (insects, diseases and weeds) in rice based cropping systems is the aim of this theme. Since type and importance of pests depends highly on crop management, input levels and weather, reduction of losses is pursued in relation to these factors. Simulation research in crop protection will therefore be carried out from the perspective of integrated control (integrated pest management, IPM). Activities will continue to determine infestation level-damage relations for major pests. Results will be translated into economic threshold levels (ETL's) for disease, insect and weed control in irrigated and rainfed rice crops under high and low levels of nitrogen input, in particular for leaf and neck blast, stemborer, and for weeds under direct seeding.

We will attempt to integrate this research on damage relations into ongoing IPM programs, such as those by IRRI and FAO in SE Asia. Association with epidemiological models developed outside SARP to include population development of pests would allow determination of ETL's in anticipation of pest development. These models should include pest-pathogen interaction mechanisms to account for biological control, such as is being developed in the ongoing 'leaf folderproject' (of IRRI and the Department of Entomology

of WAU). The other main aspects necessary for successful IPM, i.e. sampling techniques, extension and on-farm evaluation, will not be contributed by SARP, but through IRRI and FAO.

Research topics specified per theme and 'rice ecology'

The topics currently addressed by the SARP teams are listed below for all the research themes. The list was compiled from 5-year plans drafted by all the teams in January 1991. Research on most of the topics has already started during SARP-II or earlier. The list contains both process-oriented topics and applied topics.

Topics have been grouped into a matrix to enable a structured support to individual teams. The following abbreviations are used:

- ds direct seeded
- tp transplanted
- sc single crop (summer)
- dc double crop (early summer, late summer; South China)
- PP potential production
- CSM crop and soil management
- CP crop protection
- IRR irrigated rice
- IRO irrigated other crops
- RLR rainfed lowland rice
- RLO rainfed lowland other crops
- URO upland rice and other crops

(For the acronyms of names of NARCs, see Chapter 2 or Appendix 5)

A. Process and applied research at crop level and lower aggregation levels

Theme	PP	CSM	CP
Rice-ecology			
IRR	1A	2A	3A
IRO	1B	2B	3B
RLR	1C	2C	3C
RLO	1D	2D	-
URO	-	2E	-

1A

sink formation (tillering)	UPM (ds)
late grain filling	UPM (ds)
maintenance respiration	UPM, CES (ds)
photosynthesis: varietal differences	CES (ds)
low temperature effects	CES (ds)
low light tolerance and stem reserves	CNRRI (dc-tp), CRRI (tp)
parameterization varieties	CNRRI (dc-tp), SURIF
phenology leaf area	CNRRI (dc-tp)
ideotypes new vars	CNRRI (dc-tp)
ratooning	CNRRI (sc)

1B

sink limitation wheat	IARI-WTC
C-partitioning wheat	IARI-WTC
senescence wheat	IARI-WTC
varietal characterization soybean	BORIF/SURIF

1C

low light tolerance and stem reserves	CNRRI (dc-tp), CRRI (tp)
photosensitivity	TNRRI (tp)

1D

varietal characterization soybean	BORIF/SURIF
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2A

nitrogen response and efficiency	ZAU, CRRI, GPUAT
timing nitrogen application (relation to temperature)	CES (ds)
rooting (relation to temperature)	CES (ds)
balance of nitrogen to other nutrients	CNRRI
ground water pollution by nitrogen	TNAU-WTC

2B

nitrogen efficiency wheat	IARI-WTC
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2C

drought response	CRRI(ds, tp), BORIF/SURIF, TNRRI
interaction nitrogen-water	CRRI(ds, tp), BRRI
nitrogen response rice	KKU, BORIF/SURIF, CRRI, BRRI, TNRRI
iron toxicity	RARCB

2D

nitrogen response in wheat, and barley	ZAU, IARI-WTC, BRRI
nitrogen from green manures	ZAU
drought response wheat	IARI-WTC, BRRI, CAS
drought response maize	UPM
drought response peanut and soybean	KKU
water logging wheat	ZAU
water logging pulses	KKU

2E

phosphorus various crops	BORIF/SURIF, UPLB
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3A

weeds competition	UPM (ds), TNRRI
blast epidemiology-micro-climate	ZAU
damage relations stemborer	UPM, CNRRI
damage relations leaf folder	UPM, CNRRI, TNRRI
damage relations blast	CRRI, CNRRI, TNRRI
damage relations stemborer	ZAU, SURIF, CNRRI, GPUAT, BORIF/SURIF
damage relations sheath blight	GPUAT
damage relations bacterial leaf blight	GPUAT, TNRRI
damage relations gall midge	TNRRI
damage relations brown plant hopper	TNRRI

3B

damage relations in wheat (various pests)	IARI-WTC
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3C

weed competition	TNRRI
blast damage relations	CRRI
damage relations stemborer	KKU, BORIF/SURIF, RARCB
damage relations ufra	BRRI
damage relations SR	BRRI
damage relations rice tungro	CRRI
damage relations blast	CRRI

B. Applications at cropping systems and higher level

Regional zonation studies for potential production and/or water-limited production; rice and other crops

UPLB, UPM, IARI-WTC
BRRI, KGU, GPUAT
TNRRI, RARCB, BORIF/SURIF

Optimization cropping systems including identification of alternative crops; long term stability; plant spacing; crop timing; sorjan; nitrogen and drought contingency; tank irrigation

BRRI, TNRRI, ZAU,
BORIF/SURIF, CES
UPLB, CAS
IARI-WTC, TNAU-WTC

Assessment of effects of global climate change

UPM, CES, IARI-WTC,
UPLB

Screening of new varieties and design of ideotypes

TNRRI, RARCB, CNRRI

Appendix 3. Recommendations of the review team

The project evaluation included the following activities (*citation from evaluation report*):

- assessment to what extent the original objectives of SARP-II have been achieved;
- judgement of effectiveness and efficiency of project execution;
- assessment of budget allocation;
- recommendation for a follow-up beyond October 1, 1991.

(*end citation*)

The team members of the mission were J.R. McWilliam (ACIAR, Canberra, Australia), M.P. Collinson (CGIAR secretariat, Washington, USA), and D.B.W.M. van Dusseldorp (Agricultural University, Department of Rural Sociology of the Tropics and Subtropics, Wageningen, The Netherlands)

The evaluation team has also made a serious effort to answer some fundamental questions. One of the issues addressed was the choice between a broader coverage of countries, NARCs, and possibly international institutes on the one hand, and consolidation of existing teams by advanced activities and collaborative research on the other. And with respect to training activities: should they be decentralized and handed over to the national institutes or not?

Other questions were how collaborative research should be organized, how the approach can be integrated in IRRI's research program, and whether the current support in the form of team visits and theme workshops is adequate.

In terms of research focus, the review team has explicitly addressed the question whether or not socio-economic conditions and parameters must be incorporated in crop models and, therefore, whether the research in the theme 'cropping systems' should continue to represent the highest integration level for future SARP research. Moreover, the question has been addressed whether SARP should retain its current focus on rainfed environments and rice-based cropping systems.

The mission included visits to India and the Philippines, and the committee members took much efforts to interview a large number of participants from NARCs (eight teams) and collaborating IRRI staff.

The review report summarizes the committee's recommendations as follows (*citation*):

1. A new project be developed to replace the existing project; SARP-III should consolidate and extend the progress that has been achieved in building crop simulation capacity among rice scientists in the Asian region.
2. SARP-III should not attempt to expand the number of teams or countries involved in the training and support program. The geographic mandate of SARP-III should be restricted to Asia and within Asia to the nine countries in the existing program.

3. SARP's main responsibility in the next phase should be to consolidate the gains made, to ensure sustained and effective use of the modelling approach among a nucleus of national research institutes in the region.
4. SARP-III should be centered on collaborative research projects involving IRRI and three, perhaps four, of the national institutes using crop simulation modelling in the region.
5. Collaborative research sites be used as strong nodes for SARP networking and training activities, including both national and regional workshops.
6. The appropriate research staff at IRRI are involved in planning the proposed collaborative activities in SARP-III, to gain their increased support and encourage greater familiarity with the AB-DLO/TPE models in IRRI's research programs.
7. Support through visits and training workshops continues to be provided to the existing national modelling teams trained in SARP-II's three initial courses.
8. SARP project scientists assist countries in the network, such as India, with the development of their own training programs through lectures, course materials and in monitoring the quality of the training programs.
9. The collaborative projects, in their research program choices, actively seek to demonstrate the usefulness of crop simulation models, particularly in improving research efficiency.
10. Further model development in phase III should be in conjunction with interested IRRI scientists involved in the collaborative research projects. Emphasis should be on the refinement of the existing model and subroutines, and the development of additional components to simulate other identified high priority factors affecting the productivity of the crop in rainfed rice environments in the region.
11. The SARP project should retain its focus at the crop and cropping systems levels and should not attempt to integrate socio-economic components into the SARP models.
12. SARP scientists should encourage national scientist interaction with other researchers and institutions to facilitate demonstrations of the use of socio-economic factors, ex-ante to shape technical parameters in the model when appropriate, and ex-post to evaluate model predictions.

(end citation)

Appendix 4. Rice production and demand of regions in Asia

East Asia

The relative growth rate of the population in China and Korea is low for Asian standards and both are near self-sufficient in cereals. Keeping pace with growing demand, however, will be a serious problem in the coming decade. The numbers of persons per hectare of arable land are among the highest in the world (Table 1). Rice production in East Asia is characterized by high per-ha productivity (Table 2). Virtually the entire rice area is irrigated. Favorable rice growing conditions are found in the South Chinese double-rice belt (rice-rice-wheat; 22% of rice area) and Central China (rice-wheat; 66% of rice area). Target outputs in favorable areas exceed 15 ton ha⁻¹ year⁻¹ from three crops. Because production systems are already highly intensified, incremental responses to inputs are levelling off. Major concerns include the sustainability of land productivity, the low efficiency of inputs (fertilizers, biocides), environmental pollution, and the impact of future climate changes on production.

Research by the participating institutes focuses on the optimization of cropping patterns (sequence and crop choice), the breeding of varieties less sensitive to extreme weather conditions (both high and low temperatures), and the development of tailored management packages for intensive farming (soil fertility; weeds, pests and diseases). All of these require the classification and mapping of environmental conditions (zonation) and quantification of crop characteristics that express crop interaction with given climates.

In Korea, with limited farm labour availability, farm mechanisation is imperative to sustain rice production. This is associated with a shift from transplanted to direct seeded rice, calling for different varietal characteristics and different input management strategies.

South Asia

The GNP per capita is lowest among Asian countries. A high fraction (near 70%) of the labour force is employed in agriculture. On average, the number of persons per ha arable land is low for Asian standards, but population growth ranks among the highest in Asia, leading to a steep increase in demand (over 30% in this decade).

Production conditions vary within the region. Only one third of South Asia's rice area is irrigated. Conditions are favorable in the North-Western states Punjab, Haryana, Delhi and western Uttar Pradesh. Here, high yields are reached for rice and wheat, grown in rotation. Both crops are irrigated. In these intensive cropping systems, however, yields have been declining over the years. This is partially attributed to salinization, and deterioration of soil structure, resulting in poor rooting. Research focuses on rooting and water and

nutrient management under irrigated conditions, turn-around time in rice-wheat rotations, and on damage resulting from pests and diseases.

Average per-ha yields are low (1.8 t ha^{-1}) in the partially irrigated and rainfed areas of Eastern India which comprise 58% of Indian rice area (Eastern Uttar Pradesh, Bihar, West Bengal, Orissa, Assam and eastern Madhya Pradesh); and in Bangladesh, where rice occupies 80% of agricultural lands. In the rainfed areas inputs are low. Major constraints are pests and diseases, highly variable weather (floods and drought, resulting in delayed planting; and low radiation), and low soil fertility. Production systems are characterized by risk-avoiding farming strategies. In Bangladesh irrigated dry season rice cultivation is successful but considered too expensive for large areas.

To increase farm income it is essential to identify the relative importance of the various constraints at the farm level, and to specify strategies for the different environments distinguished. This involves zonation of soil and climatic conditions. Current agricultural research aims at the development of better adapted varieties for specified environments (low light tolerance; drought tolerance; flood tolerance; low temperature tolerance at grain-filling; high temperature tolerance at heading); and at optimization of cropping systems including the search for new crops and the introduction of alternative field-scale water management strategies (e.g. sorjan).

Rice farming in Tamil Nadu and other south Indian states is intensive and often irrigated. Potential yields are high. Water availability, however, has decreased lately in many areas (e.g. Cauvery delta), where now pre-monsoon dry seeding is practiced as a contingency strategy. Water is also a limiting factor in the traditional tank irrigation systems found throughout Tamil Nadu (40,000 tank systems), Karnataka and Andhra Pradesh, which the national government now seeks to rehabilitate. In these tank systems, research is directed towards farm income equity through improved sluice management and the use of supplementary community wells. Research also aims at increasing productivity by improved cropping patterns (including soybean and other pulses) and higher input efficiency.

Tamil Nadu has its own rice breeding station and releases varieties adapted to varied local conditions, that are planted throughout the southern states of India.

Rice lands in Sri Lanka are mostly irrigated, although one third of the country's rice area is in shallow rainfed lowland. Soil conditions are often unfavorable. Past increases in productivity have resulted from general country-wide recommendations. Today it is felt that further increases require developing location-specific management packages.

South East Asia

The Philippines and Indonesia share a high population density and a relatively low per capita GNP, as compared to Thailand and Malaysia. Population growth varies among these four countries, as well as the fraction of labour force employed in agriculture. Demographic and economic conditions differ also within each of the countries. This is most clearly exemplified by Thailand (Table 1) which combines two seemingly contradic-

tory features: a high GNP generated in the industrializing southern provinces, and a large fraction of the population in agricultural activities (in the rural and resource-poor north-east).

Rice growing conditions in South East Asia are highly variable as well. At the national level, highest per-ha output is found in Indonesia (Table 2), at the moment just self-sufficient in rice. At the same time, however, Indonesia faces an increase of 25% in rice consumption within this decade. While trying to amend the difficulties associated with intensive production (low fertilizer efficiency, environmental pollution, high pest and disease pressure), research focuses on alternative crops and cropping patterns, both for upland and lowland conditions. Including soybean is viewed as one of the most promising options to increase grain output. The basis for these investigations will be an inventory of climate, soils and year-round water availability. Management packages specific for local conditions must be developed.

The Philippines have to increase grain output by almost 50% to cope with rising demands over the next ten years, and by 150% to satisfy consumption in 2020. Much of the production increase will have to be realized in the rainfed lowlands where water availability is one of the main reasons for the high year-to-year variations in crop performance.

Malaysia currently imports one third of its rice demand and aims at self-sufficiency. Farming is increasingly mechanized. There is a trend towards direct seeding associated with higher labour costs, as found in other industrializing countries (e.g. Korea). As a result, weeds are a major constraint. Recently, water also has become a constraint in the off-season, directing research towards dry-seeded rainfed rice and cash crops, such as sweet corn.

While Thailand is a traditional exporter of rice, research in the context of this project addresses the resource-poor North East of the country. Major constraints in lowland production systems found here are uncertainty in rainfall (with both flooding and drought problems in pre-monsoon season), low soil fertility and the low water holding capacity of soil. Farming is based on avoiding risk in growing glutinous rice and pulses. Possibilities of improving farming systems vary much with landscape positions, and detailed site-specific recommendations are currently sought for alternative crops and input management. Improvement of rice-legume systems is emphasized. Again, zonation is a prerequisite and advanced geographic information technology is already used by the collaborating group at Khon Kaen.

Table 1. Demographic conditions in the countries participating in the SARP network. Source: Rice Facts, IRRI, 1990.

	Annual growth GNP		persons per arable land	labour force in agriculture
	rate population	US\$		
	(%)	US\$	ha ⁻¹	(%)
South Asia				
India	2.0	300	5	67
Bangladesh	2.7	160	11	70
Sri Lanka	1.3	400	9	52
S-East Asia				
Thailand	1.5	840	3	66
Indonesia	1.7	450	8	50
Philippines	2.5	590	7	48
Malaysia	1.7	1800	4	34
East Asia				
China	1.4	300	11	68
S. Korea	1.1	2690	19	27

Table 2. Rice production and consumption data for the countries participating in the SARP network. Source: Rice Facts, IRRI, 1990

	Rice area	Fraction irrigated	Rice production		Rice consumption	
			t ha ⁻¹	Mt	1989	2000
					Mt	Mt
South Asia						
India	40.1	0.35	2.3	92.4	84.5	112.6
Bangladesh	10.3	0.12	2.2	22.7	23.3	32.2
Sri Lanka	0.78	0.63	3.1	2.4	2.7	3.2
S-East Asia						
Thailand	9.6	0.14	2.0	19.2	12.9	13.6
Indonesia	10.0	0.63	4.1	40.5	39.0	50.0
Philippines	3.3	0.43	2.7	8.9	9.3	13.0
Malaysia	0.63	0.66	2.7	1.7	2.7	3.1
East Asia						
China	32.7	0.93	5.3	174.7	165	195.0
S. Korea	1.2	0.91	6.4	8.0	9.4	10.4

Appendix 5. List of Acronyms

AB-DLO	DLO-Research Institute for Agrobiolology and Soil Fertility (The Netherlands)
BRRRI	Bangladesh Rice Research Institute (Bangladesh)
CES	Crop Experimental Station (South Korea)
CNRRRI	China National Rice Research Institute (China)
CRIFC-BORIF	Central Research Institute for Food Crops, Bogor Research Institute for Food Crops (Indonesia)
CRIFC-SURIF	Central Research Institute for Food Crops, Sukamandi Research Institute for Food Crops (Indonesia)
CRRI	Central Rice Research Institute (India)
DGIS	Directorate General for International Cooperation (The Netherlands)
DLO	Agricultural Research Department (Ministry Agriculture, Nature Conservation and Fisheries, The Netherlands)
GPUAT	Pantnagar University of Agriculture and Technology (India)
IARI-WTC	Indian Agricultural Research Institute, Water Technology Centre (India)
IRRI	International Rice Research Institute (Philippines)
KKU	Khon Kaen University (Thailand)
MARDI	Malaysian Agricultural Research and Development Institute (Malaysia)
NARCs	National Agricultural Research Centres
NARCS	National Agricultural Research System
RARCB	Regional Agricultural Research Center (Sri Lanka)
TNAU-TNRRRI	Tamil Nadu Agricultural University-Tamil Nadu Rice Research Institute (India)
TNAU-WTC	Tamil Nadu Agricultural University Water Technology Center (India)
TPE	Department of Theoretical Production Ecology (WAU) (The Netherlands)
UPM	Universiti Pertanian Malaysia (Malaysia)
UPLB	University of the Philippines in Los Banos (Philippines)
'Wageningen'	the joint participating research institutes: AB-DLO and WAU
WAU	Wageningen Agricultural University (The Netherlands)
ZAU	Zhejiang Agricultural University (China)

