IRRI–ICRISAT Meeting on Ecoregional Approaches

Report of the Meeting
held at ICRISAT Center,
20–22 April 1993

IRRI
International Rice Research Institute

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics

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Principal Outputs

(1) The Centers agreed that TAC AEZ 2 (sub-humid tropics) is the priority AEZ for collaborative rice-legume systems research.

(2) An inventory of existing data bases in each center, identification of appropriate existing models (and data requirement) and establishment of uniform data codes and field structure for digital map data for inclusion in GIS will be collected before December 1993.

(3) There will be exchange of personnel to facilitate standardization of our activities.

(4) District-level data on agricultural production and management will be collected for India by ICRISAT and made available to IRRI.

(5) Information and documentation for rice-legume systems will be collected in the following areas: nutrient (N+P) cycling, water use efficiency, pests and diseases, soil physical and biological properties, socio-economic indicators, and system level agriculture.

(6) A follow-up meeting to include NARS and other IARCs (at least CIMMYT) is scheduled for 7-10 December in Bangkok (AIT).

The International Rice Research Institute (IRRI) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) are in the process of developing an ecoregional cooperative research program for South and Southeast Asia. As this is the first effort of its kind among CGIAR centers in Asia, this process can serve as a model for establishing a coordinated, synergistic, and cost-effective research agenda within an Asian ecoregional context.

A first meeting between IRRI and ICRISAT was held at IRRI in Los Banos, 1-2 October 1992. At that meeting IRRI and ICRISAT agreed to collaborate on research in the warm semi-arid tropics, the warm sub-humid tropics, and the warm semi-arid sub-tropics (TAC AEZs 1, 2, and 5, respectively). AEZ 2 in particular meets the requirements for a priority area because there is large population pressure on a limited and degrading natural resource base, the impact of green revolution technologies has largely by-passed this region, and there are tremendous social inequities as indicated by very high proportions of rural and urban poor. It was agreed that joint activities would include developing and maintaining common data bases using common software for GIS applications for all AEZs in Asia. Research will focus on factors related to degradation of production systems in which mandated crops for the Centers are involved. Emphasis will be on issues of nutrient cycling, depletion, and potential for enhancement in rice-legume systems in rainfed and irrigated systems.

It was further decided that two more meetings between IRRI and ICRISAT would be held in 1993: one meeting at ICRISAT Center in Patancheru, 20-22 April, where the Asian Institute of Technology (AIT) would be invited, and one meeting at AIT in Bangkok, 7-10 December, where representatives of NARSs would be invited.

The meeting at Patancheru was attended by 26 participants: 5 from IRRI, 1 from AIT, and 20 from ICRISAT (see Appendix 1). Dr. V.P. Singh from IRRI also intended to attend the meeting, but fell ill and had to stay behind in Delhi. The meeting was open for all scientific staff from ICRISAT and a varying number of ICRISAT scientists attended the meeting as observers.

The program for the meeting was divided in 4 blocks of half a day each (see Appendix 2).

In Block I, ecoregional approaches to agricultural research were discussed, as well as the research agendas of IRRI and ICRISAT as described in their respective Medium Term Plans.

Block II focused on minimum datasets for agroecological zoning and characterization, and for soil-crop modeling. Other topics related to the collection and exchange of information in cooperation with the NARSs and the role of GIS in systematizing geographically referenced information.

In Block III, issues for future collaborative research were discussed. Sustainability problems related to rice-wheat and rice-legume based cropping systems were discussed. The role of simulation modelling and systems analysis was highlighted.

In Block IV, the participants were divided into four working groups (WGs).

The first WG dealt with minimum datasets for agroecological zoning and with mechanisms, spatial units, and GIS. Participants in this WG included E.D. Hunt (convener), S.M. Virmani (soil and climatic data), T.G. Kelley (socio-economic data), and P. Mohan Rao (GIS).

The second WG dealt with crop modeling and systems analysis, rice-legume multicrop models and minimum datasets from crop modeling. Participants in this WG included M.J. Kropff (Convener), N. Vidyalakshmi, Piara Singh, G. Alagarswamy, and N.K. Awadhwal. As the convener had to leave the meeting before 1600 hours, the recommendations of this WG were presented by E.D. Hunt, together with those of WG 1.

The Third WG dealt with research issues related to rice-legume based systems (problems, constraints, opportunities). Emphasis was on rainfed lowland systems in AEZ 2 (sub-humid tropics) where rice yields are generally low and have increased very little over the past 2-3 decades. It was felt that the possible role of legumes in improving the productivity of these systems should be investigated. Participants in this WG included K.G. Cassman (Convener), C. Johansen (Legumes), J.K. Ladha (Legumes), and J.A. Wightman (Entomology).

The fourth WG dealt with ecoregional cooperation and coordinating mechanisms (consortia, networks), the involvement of NARS, and the preparation of the meeting at AIT in Bangkok, 7-10 December 1993. Participants in this WG included Gajendra Singh (Convener), R.S. Zeigler (consortia), C.L.L. Gowda (networks), and K.F. Nwanze (NARSs).

In the final session of the meeting (21 April, 1615-1645) the recommendations of the WGs were presented by the conveners and briefly discussed.

Rapporteurs' Reports

Block I: Opening Session and Ecoregional Approaches

Chair : K. Harmsen *Rapporteur* : C.L.L. Gowda

Director General's opening remarks:

The IRRI-ICRISAT discussions on ecoregional approaches began in October 1992 at IRRI to explore possible implications to both institutes. This meeting is to continue that dialogue.

- Three agroecological zones (AEZ 1,2, and 5) were identified as areas of common interest to both institutes. Options on other AEZs were kept open.

- Agreement was reached on having common data bases and software for facilitating exchange of data between the institutes.

- Broad areas of collaborative research between both institutes were identified.

- Since that meeting, both IRRI and ICRISAT have submitted their Medium Term Plans (MTPs) to the TAC. The MTPs should provide ample information for our discussion.

- The TAC Working Group paper on Ecoregional approaches has been circulated to the Centers recently. A few concerns are:

  - IARCs role in the whole exercise is that of a Convener of Consortia, without implicit (explicit?) research responsibilities;
  - The paper does not clearly state the extent to which IARC's should act to catalyze the AEZ activities;
  - There are no clear indications of the extent of strategic, applied on-station, and adaptive on-farm research in the system;
  - The limited time horizon for natural resource management research is insufficient to show any impact.

- More input is expected from this discussion meeting, the results of which will then be discussed at the Puerto Rico workshop in May 1993.

- The meeting with NARS representatives in Dec 1993 at AIT, Bangkok, will provide guidelines for our future work in this regard.

K. Harmsen presented an overview of ecoregional concepts:

- FAO initiated the agroecological zone (AEZ) concept in 1978, using the length of growing period (LGP). Where rainfall was sufficiently high to recharge the soil, the water holding capacity of the soils was held constant (100 mm).

- TAC recognizes 9 AEZs:

  AEZ 1: Warm arid and semi-arid tropics
  AEZ 2: Warm subhumid tropics
  AEZ 3: Warm humid tropics
  AEZ 4: Cool tropics
  AEZ 5: Warm arid and semi-arid subtropics (with summer rainfall)
  AEZ 6: Warm subhumid subtropics (with summer rainfall)
  AEZ 7: Warm/cool humid subtropics (with summer rainfall)
  AEZ 8: Cool subtropics (with summer rainfall)
  AEZ 9: Cool subtropics (with winter rainfall)

- TAC recognizes four regions with 23 regional AEZs (RAEZs):

- Latin America and Caribbean (LAC)	9 AEZs
- West Asia and North Africa (WANA)	3 AEZs
- Sub-Saharan Africa (SSA)	4 AEZs
- Asia	7 AEZs

While preparing RAEZ's some information has been lost by merging different AEZs in line with political boundaries of countries.

Ecoregionality envisages merging of commodity improvement and resource management research with a focus on sustainability.

Coordination of efforts of NARS and IARC's in the region is essential for efficiency of research and targeting global/regional issues.

Coordinating mechanism can be convened by an IARC or regional entities, such as SACCAR in Southern Africa.

Consortia approach involving partnership and joint planning by diverse institutions having common interest to create a critical mass needed to address the ecoregional issues is essential.

Discussion

- Concern was expressed regarding merging of AEZs by TAC to arrive at 23 RAEZs. This has resulted in loss of informaton. However, it was argued that disaggregation and refining AEZs of interest is necessary by the concerned IARCs.

- Ecoregional issues should consider whether we can have the responsibility for going from strategic to applied to adaptive research and be able to show impact in 10 years; particularly if we (IARC) are to act only as conveners.

- The consensus was that the IARCs should be fully involved in the research process, using comparative advantages and expertise of each player. IARCs may also be the conveners to bring together the actors, put-forth a common program for implementation, and integrate the joint research outputs.

- Ecoregional responsibility/mandate encompasses all crops in the farming systems in the area, and is not restricted to the IRRI/ICRISAT crop mandates only.

- Some IARCs have initiated programs in this direction, and we could learn from them.

- Modeling should be done by mentor institutes, and only refining and applications to be undertaken by IARCs.

TG Kelley presented ICRISAT MTP research agenda with reference to research domains. Research domains are defined as relatively homogeneous regions where impact of strategic research will be pervasive. The domains were defined by the scientists as zones of adaptation based on crop features and constraints (not just on the basis of soils and climate).

S.M. Virmani presented congruence of crop domains with AEZs. There was moderate congruence in India, but limited congruence in Africa.

R.S. Zeigler presented IRRI's proposed MTP research agenda, as related to the four rice ecosystems: upland, lowland rainfed, irrigated lowland, and deepwater rice ecosystems. Aspects of ecoregional research with regard to rice production such as: raising yield ceiling, system intensification, and reduced losses to pests/diseases were to be integrated across all research programs. Projects are organized within ecosystems, unless these are common across ecosystems.

- During discussions attention was drawn to the low and stable yield of rice in AEZ 2. This zone provides tremendous opportunities for increasing the yield levels. Role of legumes and resource management collaboration in this AEZ was emphasized.

Block II: Data bases, Information Exchange, and GIS

Chair : R.S. Zeigler *Rapporteur* : A. Ramakrishna

E.D. Hunt presented progress on data base and agroecological zonation achieved by IRRI. He stressed the need for collapsing the information and for decrease in large scale spatial units, since spatial units form the basis for creating agroecoregional zones. He also emphasized the need to collect primary data in both tabular and spatial forms. Combinations of thematic data then form the basis for defining an ecoregion.

There is a need for refining the TAC proposed AEZ's by using original FAO thermal LGP and precipitation categories, and removing the additional TAC modifiers. This process allows discrete FAO isoline units and usage of FAO defined maps. Some of the IRRI accomplishments mentioned were viz.,

- by using FAO's digital data base for south and southeast Asia, IRRI has digitized all the Huke maps for rice,
- overlaid Indian districts on FAO base map,
- identification of districts by AEZ's and
- development of SSD data base district-wise.

However, he pointed out that they have not yet

- included China, Bangladesh and India country AEZ's,
- added FAO soil-data,
- included additional parties,
- developed data base standards or exchange/curation methods.

P. Mohan Rao gave an overview of GIS facilities existing at ICRISAT and indicated future plans.

S.M. Virmani presented agroclimatic data base available at ICRISAT. He discussed minimum datasets required for delineation of agroecological zones meaningfully. In order for a minimum dataset to be identified, there is a need first to identify the set of purposes for research themes to guide the structure of data base development. It was pointed out that most institutions have datasets but are loosely organized and for ecoregional or cross institutional approach there is a need to inventory data bases currently in use or archived.

T.G. Kelley presented ICRISAT research agenda and referenced it to research domains. These domains were defined by the scientists as zones of adaptation with crop features and constraints and not on the basis of soils and climate. ICRISAT has collected a large number of data on VLS pertaining to India. He however, mentioned that ICRISAT has very limited information (mostly collected from FAO) about other Asian countries. This can be obtained by coordinating with IFPRI, ADB, CPGRT etc.

J.A. Wightman presented pest and disease data base. He indicated that ICRISAT has developed good data base on all its mandate crops. However, there is a need to identify the major indicators like soil, temperature, climate etc. to get information precisely about the disease and insect problems based on AEZs . For this, particular situation need to be identified clearly to set the objectives and identify the insect and disease problems for collecting the dataset. The group felt that proper sites should be selected to collect the dataset for using the resources prudently. The powerful tools that need to be used and data collected to be identified well in advance for collecting meaningful data.

L.J. Haravu presented a brief review of information-related issues including ICRISAT's strengths in information management, possible IRRI-ICRISAT collaboration, and actions that can be initiated. He pointed out that ecoregional approach calls for close links and partnerships with the NARS. IRRI and ICRISAT should share the responsibilities for information services to identify research themes/projects and take up joint projects to improve information access and handling the Asian NARS. Obviously, this needs to be done with long-term perspective.

Block III: Issues for Future Research

Chair : R.S. Zeigler *Rapporteur* : Belum V.S. Reddy

This session primarily examined the possible research areas wherein both IRRI and ICRISAT may positively contribute to enhancing overall productivity of the system in the given agroecological zones.

K.G. Cassman spoke on the work carried out under phase 1 of the Rice-Wheat Project, a collaborative effort between IRRI, CIMMYT, and several NARS in South Asia. Rice-Wheat systems spread over 25 m ha in Asia cutting across two agroecological zones. He also pointed out the characteristics of the system that argued for an eco-regional approach encompassed in this project and outlined the research issues for the phase II program.

F.R. Bidinger surveyed sorghum production in Asia. He indicated that there are possible upland areas in East Asia where maize can be profitably replaced with sorghum for feed and fodder. In rice based system, sorghum may find its use as forage crop, but he posed the question, whether this would be advantageous especially when leguminous fodder varieties are available. He further pointed out that market channels for sorghum were not developed, therefore sorghum may not attract the farmer in East Asia. In South Asia, he said, that sorghum is a major food grain and also both dry and green fodder crop, and also it can favourably compete well with maize in drier areas. However, in irrigated rice-based system, he concluded that sorghum was a too low value a crop to compete with other cash crops and leguminous crops. Probably, sorghum may be grown as a forage crop or for seed after rice in small areas. A summary of the presentation of F.R. Bidinger is given in Appendix 3.

During the discussion, it was pointed out there is a need to study the system in a more systematic manner as the data on even important parameters are not available. Also, low lands in North East Thailand may have potential for sorghum. Millet may be preferred as a contingency crop after rice, because of high susceptibility of sorghum to shoot fly. It was also pointed out that sorghum seed production may be a more profitable proposition after rice. Also, perennial sorghum cultivars may have potential to grow in hedge-row system or on bunds in rice fields to prevent erosion and to be of use as forage/grain.

J.K. Ladha described the advantages of rice-based legume systems, and presented the methods he used to monitor nitrogen contributed by legume crops and the results obtained by studying different systems following rice - *Sesbania rostrata*, *Gliricidia*, mung bean, soybean, and *Cassia* (a non N-fixing legume), weedy and weed-free. *Sesbania* topped all in enriching soil by adding 53 kg N ha^{-1} through fixation, while mung bean added 17 kg N ha^{-1}, and soybean depleted N by 14 kg ha^{-1}. Further research issues include studies on phosphorus management, role of impervious hard layer, effects of the reduced soil bulk density, etc.

During the discussion, it became clear that rice-legume system is more advantageous than rice-wheat system, and among the legumes, *Sesbania* adds to the productivity of the soils more than grain legumes and groundnut. Discussion centered on whether the system should aim at sustaining/enhancing the soil productivity or the returns to the farmers. It was clarified that both are important, and that farmer adapts the system readily where he sees short term and medium term gains. It was also pointed out that the role of some existing practices (e.g., summer-deep ploughing in adding to the system's productivity) should be further studied.

C. Johansen spoke on legumes in rice cropping systems based on ICRISAT experience. He enumerated the advantages of legumes in rotation after cereals. Characterization of rice growing areas through GIS and modeling and development of short duration pigeonpea, chickpea and groundnut cultivars were identified as the legumes program agenda at ICRISAT Center (IC). He further enumerated specific constraints for each crop in rice-based legumes systems such as i) temperature and photoperiod insensitivity, ii) disease and pest resistance, iii) early vigour, vi) deep root system, v) acid tolerance, etc. He said that characterization of soils in rice system in relation to legumes, changing rice/wheat cultivars to fit legumes, developing expertise on other non-mandate leguminous crops, and on farm research were the issues for further research. A summary of the presentation of C. Johansen is given in Appendix 4.

During the discussion, it was pointed out that in addition to sustaining productivity, other socio-economic factors such as dietary habits, marketing, government policies, etc., should be considered in formulating the improved systems research. It was concluded that IC bred varieties such as short duration, wilt resistant, and mosaic resistant varieties in pigeonpea, and early varieties in groundnut and chickpea can be tried immediately. There are many areas in rice-legume system where IRRI and ICRISAT may fruitfully cooperate in studies leading to the enhanced system productivity.

M.J. Kropff spoke on simulation modeling and systems approach. He indicated several areas where modeling can be used profitably in agroecological research. Areas of use: to reduce experiments to focus research, to integrate knowledge from different fields, to identify research gaps, as an analytical tool (as opposed to statistics), to quantify crop environment interaction, etc.

During the discussion, the need for training to keep pace with the changing components of modeling, the difficulties involved and the time period in collecting the critical data to drive the models, and the role of IARCs in training the NARS scientists in such techniques were emphasized.

Finally, C.L.L. Gowda presented a paper on rice-legume, and rice-wheat cropping systems - issues for further research. He prefaced his talk by stating that his presentation was a summary of the presentations made earlier. He described briefly the four ecosystems of rice: rainfed upland, rainfed lowland, irrigated lowland, and deepwater ecosystems. He also described briefly the situation prevailing before and after rice cultivation and listed various types of constraints: hardening of the subsoil after rice cultivation (leading to increased bulk density, decreased infiltration rate and aeration); destruction of soil structure; reduced organic matter; increased production of phytotoxic compounds; specificity of cultivars to sowing date; need to deep plow; root injury due to the development of temporary perched water table; low phosphorus availability; terminal drought. At the end he outlined possible areas of collaborative research in RBCS. They were: delineation of agroecological zones using GIS and soil structure, nutrient, and BNF management, crop establishment and crop growth studies. A summary of the presentation of C.L.L. Gowda is given in Appendix 5.

A general discussion followed. This centered on two areas - (1) models - number of models, and level of accuracy of these models, availability of data on all critical sub-routines, etc., and (2) availability of quantitative data on various parameters such as N-balance, energy balance, infiltration rate, acidity development rate, diseases and pests pattern etc., It was pointed out that two critical datasets - water balance and N-balance were required as inputs, and the dataset on the first were on the way, and data on the other still to be collected. It was noted that data on various parameters especially N-balance associated with different cropping systems were available, but scattered.

Chair : K. Harmsen *Rapporteur* : Piara Singh

Report of Working Group I

Convener : E.D. Hunt

This working group was charged with addressing the following:

- Minimum Datasets for Agroecological Zones
- Spatial Units
- Mechanisms
- GIS
- Modeling

The consensus of groups is the following:

1) In order for a minimum dataset to be identified there needs to first be a set of purposes or research themes to guide the structure of dataset development.

   a) the building of huge datasets for the sake of collecting data is thought to be inefficient.

   b) most institutions have datasets - all-be-it loosely organized - but that suffice for the research activities currently at hand.

   c) for ecoregional or cross-institutional approaches there is need to inventory data bases currently in use or archived.

   Action: Inventory the data bases that are housed at each Center. Elements of to be included are:

   List by country.
   Include time period covered (years of census, years of trials...etc).
   The variables (fields) that are contained in the data bases.
   What software does the data reside in.
   What is the status of the data (paper, digital, in process of digitizing...etc).
   The source of the data.
   Bibliographic/Library data.
   List of GIS or Remote Sensing data (country, theme, format...etc).
   List of paper maps and aerial photographs.

2) The result of the dataset survey forms the "existing dataset". This

   a) identifies GAPS related to areas of common interest. Filling of critical gaps may help identify research themes.

   b) identifies the spatial and tabular data that can be used as a basis for initial ecoregional activities (an ecoregion can be an RAEZ, as defined by TAC, or an area that is smaller or equal in area to a RAEZ, but with a spatial extent that is defined by the research theme(s). [Working Group Three has suggested an initial research theme for IRRI-ICRISAT collaboration.]

   c) can form the basis for bringing NARS/others into "ecoregional" research, first to assist in filling in the gaps, then participating in identified research activities.

   d) aids in understanding the compatibility of existing datasets and the amount of work required to integrate data between Centers/NARS/others.

   Action: Need to define Research Theme(s).

3) Spatial Units are defined by research theme(s).

   a) GIS is used to identify the limits/locations of the Spatial Units.

   b) Modeling and GIS can be used in a cycle of planning and analysis.

   *Position: It is better to generate ecoregional units based on research questions/problems developed in collaboration, then to impose an artificial or rigid structure (e.g., RAEZ) and attempt to "shoehorn" into it. A flexible system is needed that allows information to be aggregated for regional or global reporting, as required, but one wherein the resolution is retained (See Figure 1 on page 15 of this report).

   Action: Agree upon a reporting method for aggregating ecoregional research. Hunt has proposed a model that needs to be reviewed and discussed, as well as other ideas.

4) To carry out collaborative/ecoregional research a detailed set of exchange and coordination mechanisms should be established.

   a) in order to interface with NARS/others.

   b) facilitate the movement, storage, retrieval of data.

   c) to coordinate research activities.

Position: This requires the development of standards for information exchange. Standards for exists in some areas (e.g., codes for geopolitical entities, latitude/longitude...etc), but within the CGIAR and NARS further standards are needed.

Action: Include Computer Services and Information Management people in December meeting to plan the process of assembling an information exchange system.

Comment: Developing IRRI-ICRISAT collaborative research has broader application in that they will be forging guidelines and procedures that other Centers can then use. The Centers should examine the approach taken in East and Southern Africa to benefit from the experience of several Centers that have undertaken a similar task.

Short-term Activities (6-12 months with reports/presentations to be given in December):

1) Inventory of data bases at each center (Hunt/Kropff/Anders/Virmani/Whitaker)

This should:

be organized by country,

identify temporal ranges, and associated variables/fields,

identify software format, and the source and status of the data (paper, computer, in process of computerization),

distinguish bibliographyic/library data from GIS and remote sensing data – digital and paper formats.

GIS and remote sensing data.

2) Modeling (Kropff/Vidyalakshmi/Singh):
exchange personnel.
develop and apply a cropping system model.
identify a set of models to be used (along with the required data for each model).

3) GIS (Hunt/Rao)
exchange of personnel.
establish uniform data codes and field structures of digital map data

4) Mechanisms (Denning?/Shenoi/Gowda)
interfaces with NARS/other
inventory of NARS data - what they have and what they can use
invite NARS/others to Bangkok (need to interface with
activities of Working Group Three).

Long-term (for the next five years):

1) Fill in gaps in data as they relate to the onset of research themes.
2) Develop a set of Benchmark Sites (50-80 sites).
3) Active involvement with ICASA.
4) Develop a rice/legumes model.
5) Develop a linkage with GIS/DBMS/Modeling.
6) Finalize standards for information exchange and data repositories.

Scale and Resolution of Attributes		**Extent**	**Domain**
Small Scale	MEGA - general (few)	World/Regional	TAC Planning
	MACRO	Regional/Country	Center Planning (Inter and Intra)
	MESO	Province/State District	Inter Center Planning
Large Scale	MICRO - specific (many)	Village	Experimental/Trials

Figure 1. The conceptual framework of scale of analysis versus the relationship to aerial extent and management domain. Small scale (Mega level) approaches are general and contain few attributes. Large scale (Micro level) approaches are specific and contain many attributes. CGIAR centers operate at the Macro to Micro levels. TAC operates at the Mega or world-wide level. Any AEZ system developed must be transparent and move up or down in scale.

Report of Working Group II

Convener : K.G. Cassman

This group focused their deliberations on long and short-term research issues related to crop production in agroecological regions common to the IRRI/ICRISAT research interest.

Long-term issues:

1. There is need to study the long-term benefits and risks associated with diversity and intensification of cropping systems in seasonally dry environments with a high element of uncertainty.

2. Identify barometers of on-farm and off-farm resource quality (eg. soil, landscape, watershed) governing long-term performance.

3. Need to develop common approaches to pest and nutrient digital and paper formats management with the objective of developing compatible technology for rice and legume components.

Short-term issues:

1. There is a need to collect and collate district-wise data pertaining to yields, area, total production, and inputs etc., for rice and legumes grown in AEZ 2. [Kelley and Johansen]

2. Collection of information and documentation concerning rice-legume interactions on the following:

   - Nutrient cycling–N and P. [Johansen/Ladha]
   - Water use efficiency. [Legume–Flower; Rice–Zeigler to assign T.P. Tuong]
   - Pests and diseases. [Wightman/Zeigler]
   - Physical properties of the soil. [Awadhwal]
   - Biological properties of the soil. [Wani/Ladha]
   - Sociological indicators. [Bantilan]
   - System level synthesis. [Johansen]

Exercise to be conducted will cover relevant rice-legume systems to reveal gaps in knowledge. Discussion papers will be presented at the December Meeting in Bangkok to help target future research efforts. Specialists from NARS, IRRI, and ICRISAT will attend the Bangkok meeting. Representation from AIT, AVRDC, CIMMYT, CGPRT, IBSRAM, ICRAF, and FAO should be considered.

Report of Working Group III

Convener : Gajendra Singh

This working group was to plan for the "Regional Discussion Meeting on Ecoregional Approaches" to be held in Bangkok. The purpose of the meeting will be to discuss with NARS the ecoregional approaches to development of sustainable and improved farming systems. Other details regarding the forthcoming meeting are as follows:

Date	December 7-10, 1993
Venue	AIT, Bangkok
Co-sponsors	ICRISAT-IRRI-AIT

Participants:

a) NARS – The participants will be invited from the AEZ-2 (primarily) and AEZ-5 (secondarily) of India, China, Thailand, Pakistan, Sri Lanka, and Myanmar. At this stage Myanmar and Sri Lanka may not be necessary. The participants from the NARS (India, China, Pakistan and Thailand) must have authority to commit resources and be technically qualified to participate in the discussions.

b) Existing consortia – 4 participants from the existing consortia on i) Rainfed lowland rice; ii) Rice-wheat consortium; iii) Legumes resource person; and iv) others, if any.

c) IRRI – 5

d) ICRISAT – 5

e) AIT (Bangkok) – 5 at no costs

f) Others like FAO, CIMMYT, CGPRT, IBSRAM, ICRAF, AVRDC, IIMI – 5

g) Thailand (host country) – 2 observers
Total participants = 30

Coordination:

Technical aspects – IRRI and ICRISAT
Logistics/Physical facilities – AIT

Invitation letters to be jointly signed by IRRI and ICRISAT. AIT will provide hotel rooms at reduced rates, meeting rooms etc. will be from the department.

Program:

2 days for presentation by IARCs and NARS
½ day for GRID-Bangkok (demonstration)
½ day for visit to farmers' fields
½ day for discussion group meetings
½ day for final recommendations etc.

General Discussion:

After the group reports the following points were raised:

Hunt : Consultant from IRRI, who is expert in mechanisms of exchange of information, should be invited to the December meeting in Bangkok.

Cassman : We need to define the focus of the meeting and therefore narrow down the number of invitees most relevant to the purpose of meeting.

Nwanze : All people who will get involved in the project later on should be invited so that they get introduced to the subject at earlier stages.

Harmsen : In principle we should have maximum possible participation in the meeting, but we have to consider funding before we extend invitations.

Zeigler : We need to consider the participation of the people who are part of the already existing consortia.

Harmsen : One of the aims of the Bangkok meeting would be to prepare a proposal for funding an ecoregional project targeting AEZ 2.

Closing comments by J.G. Ryan:

I am pleased to note that the outputs of the workshop are very clear in terms of short- and long-term goals. We should consider the funding requirements for both the Bangkok Workshop and the long-term project for the ecoregion of common interest to IRRI and ICRISAT. TAC does not limit resource management research to commodities, therefore we will have to think beyond the mandate crops of ICRISAT and IRRI. The agenda of the meeting should not be so broad as to lose focus. A challenge for us will be to decline requests for attendance to the meeting. Attendance should depend upon the agenda. The most appropriate title for the meeting, perhaps, should focus on characterization of environments with view to find research strategies for rice-based systems.

IRRI-ICRISAT Ecoregionality Meeting
20-22 April 1993

List of Participants

IRRI, Philippines

R.S. Zeigler

K.G. Cassman

E.D. Hunt

M.J. Kropff

J.K. Ladha

AIT, Thailand

Gajendra Singh

ICRISAT, India

J.G. Ryan

Y.L. Nene

Karl Harmsen

D. McDonald

J.A. Wightman

C. Johansen

F.R. Bidinger

K.F. Nwanze

T.G. Kelley

D.J. Flower

S.M. Virmani

C.L.L. Gowda

M.V. Reddy

Jagdish Kumar

P. Mohan Rao

G. Alagarswamy

A. Ramakrishna

N.K. Awadhwal

B.V. Subba Reddy

L.J. Haravu

Appendix 2

IRRI-ICRISAT Ecoregionality Meeting
20-22 April 1993

Venue: 212 Conference Center

Arrival of IRRI and AIT participants Mon 19 and Tue 20 Apr 1993

Tue 20 Apr 1993

Block I: Opening Session and Ecoregional Approaches

Chair : Karl Harmsen
Rapporteur : C.L.L. Gowda

0900-1230	▪ Opening Remarks	J.G. Ryan
	Ecoregional Mechanisms: Report of the CG Working Group	Karl Harmsen
Tea/Coffee 1030-1100	ICRISAT's proposed MTP research agenda	T.G. Kelley S.M. Virmani
	IRRI's proposed research agenda	R.S. Zeigler

Block II: Data bases, Information Exchange, and GIS

Chair : R.S. Zeigler
Rapporteur : A. Ramakrishna

1400-1645	▪ Progress report by IRRI on data base and AEZ	E.D. Hunt
	▪ Progress report by ICRISAT	
	- GIS (Phase I and II)	P. Mohan Rao
	- Agroclimatic data base	S.M. Virmani
	- Economic data bases	T.G. Kelley
	- Pest and disease data base	J.A. Wightman
	- Information Exchange	L.J. Haravu
	▪ Discussion	

Wed 21 Apr 1993

Block III: Issues for Future Research

Chair : R.S. Zeigler
Rapporteur : Belum V.S. Reddy

0830-1200	▪ Rice-cereal system	K.G. Cassman
	▪ Cereals in rice cropping systems	F.R. Bidinger
	▪ Rice-legume system	J.K. Ladha
Tea/Coffee	▪ Rice-legume and rice-cereal cropping systems-issues for future research	C.L.L. Gowda
	▪ Legumes in rice cropping systems	C. Johansen et al.
	▪ Simulation modeling and systems approach	M.J. Kropff
	▪ Discussion	

Block IV: Networks and Recommendations

Chair : Karl Harmsen
Rapporteur : Piara Singh

1400-1645	▪ Introduction to the Working Groups	Karl Harmsen
	Working Group 1: Minimum datasets for AEZ and modeling *Conveners*: E.D. Hunt (GIS) and M.J. Kropff (modeling)	
	Working Group 2: Research issues *Convener*: K.G. Cassman	
	▪ Working Group 3: Ecoregional mechanisms *Convener*: Gajendra Singh	
Tea/Coffee	▪ Recommendations of the Working Groups	E.D. Hunt K.G. Cassman Gajendra Singh
	▪ Closing Remarks	J.G. Ryan

Thu 22 Apr 1993

- Meetings
- Visiting Labs/facilities
- Departures

Sorghum in cropping systems in Asia

F.R. Bidinger
International Crops Research Institute for the Semi-Arid Tropics

I. Areas and Systems in Asia

India is the dominant producer of sorghum in Asia with more than 15 million hectares under sorghum cultivation. The crop is grown in three major systems: (1) dryland cultivation in semi-arid zones (500 - 1000 mm rainfall areas) during the southwest monsoon in the Deccan plateau (Maharashtra, Karnataka, and Andhra Pradesh) and bordering areas in Madhya Pradesh, Gujarat, and Rajasthan, and during the northeast monsoon in Tamil Nadu; (2) on stored soil moisture following the rainy season in Vertisol areas in the western Deccan plateau (Maharashtra and northern Karnataka); and (3) under irrigation in the Indo-gangetic plains, entirely as a green fodder crop. Sorghum and rice overlap in system 1 in Andhra Pradesh, Karnataka and Tamil nadu, but occupy very different niches in the farmers' systems. Rice is found in the irrigated, often alluvial soil areas and sorghum in the dryland, often light textured soils.

China is the only other major Asian producer, with an estimated 1.9 million hectares. The crop is grown mainly in the semi-arid temperate areas in the north and east of the country. The area sown to sorghum has declined from an estimated 5 million hectares less than 20 years ago, as the crop is being replaced by more valuable alternatives.

Other countries in Asia producing sorghum do so on relatively small areas: Pakistan 380,000 ha, Thailand and Myanmar 180,000 ha each, and Indonesia 20,000 ha. Others such as the Philippines cultivate only a few thousand ha each. The crop in these countries is mainly grown in areas too dry or on soils too poor for maize or other cereals, both in the main (rainy) and dry seasons. There does not appear to be important examples of ares in which rice and sorghum cultivation overlap, or in which the two are grown in rotation, although our knowledge of sorghum cultivation in east Asia is very limited.

II. Utilization and Variety Requirements

Sorghum in south Asia is primarily food grain, consumed on the farm. Not more than a quarter of the total production reaches the market. Very little goes into feed or industrial uses at present, as there is little price incentive to substitute sorghum for other crops (primarily maize, which is increasing in production in north India). In much of the dryland area in both the rainy and post rainy seasons, farmers cultivate dual purpose varieties as the requirement for fodder for cattle is equally important as the requirement for grain for human food. Variety requirements in these areas are for intermediate to tall, white grain, medium maturity (110-120 day) types. Post rainy season sorghum commands a premium market price (equal to wheat) because of its high quality, large, mold-free grain. New varieties for this area must possess the same grain quality as traditional varieties. The requirement for fodder varieties is for both single and multiple cut types. Main biotic constraints for which resistance is required are shootfly and stem borer universally, and striga, midge and grain mold in specific production areas or maturity types.

Sorghum in Southeast Asia is almost exclusively a feed crop except in Myanmar and parts of China, where it is used for food and brewing. Varietal requirements are primarily for early (100 days), dwarf, grain type cultivars, especially in the grain areas. Requirements for grain characteristics apparently are determined by local market requirements. Thailand, for example, has developed an attractive export market for feed sorghum in Japan, where red grain is preferred. In other areas, white grain is the traditional preference. Varietal requirements may differ for rainy and dry season cultivation, if daylength and temperature differ between the two seasons. Requirements for resistances to pest and diseases vary among countries and growing seasons. Leaf diseases resistance and possibly grain mold resistance are probably the priorities for the wetter areas/rainy season crop.

III. Prospects for Sorghum in Rice-Based Systems in Southeast Asia

Sorghum as an upland crop

In areas where rainfall and/or soil water storage capacity are marginal for maize, sorghum is a potential replacement for maize for feed and fodder uses. It should be relatively straightforward to breed cultivars with the required duration, stature, pest and disease resistances (except perhaps grain mold resistance), and grain type, if requirements are clearly defined. The main limitation to the expansion of sorghum area in Southeast Asia appears to be the lack of established markets for the crop, with the exception of Thailand, where an export market for feed sorghum exists.

Rice-sorghum rotations

We are not aware of areas in Southeast Asia in which sorghum is regularly grown after rice in the rotation. Further, it is not apparent what advantages sorghum might present in rotation with rice, in wet/dry seasonal areas. Grain legumes or oil seeds would be expected in most cases to more profitable than sorghum as a rotation crop, and rice-legume rotations would be expected to have agronomic advantages over a rice-sorghum rotation. The requirement for a feed grain in rice-based farming systems should be more easily supplied by maize than by sorghum in Southeast Asia, except in areas where irrigation/rainfall in the dry season is inadequate for maize. Sorghum may be useful as a source of green fodder for domestic use in the dry season, as in India, but for agronomic reasons a leguminous fodder crop or a grass/legume mixture would probably be preferable to sorghum in a rice-based system, particularly if the farmer was not willing to invest in nitrogen fertilizer on the sorghum fodder crop.

IV. Prospects for Sorghum in Rice-Based Systems in South Asia

Sorghum as an upland crop

Sorghum will continue to be an important crop in upland areas in south Asia, for both environmental and cultural reasons. Sorghum is a major food grain, along with rice, in South India, and actually the preferred food grain in parts of Central India. Sorghum is also the primary source of both dry and green fodder in much of semi-arid India, for farmers who are absolutely dependent on a cultivated fodder source to keep their draft and milk animals. Sorghum should be a prime candidate to meet the expected increase in demand for feed grain in the semi-arid areas, as maize is too risky in most of the dryland areas, and it is uneconomic to use irrigated land for maize for feed grain production. For sorghum to complete with maize in the national feed grain market, yields will have to be raised to lower production costs below those of maize. Present market opportunities for sorghum are unattractive, however, and farmers who are able to raise sorghum yields are diverting part of their land to more marketable crops: cotton, sunflower and pulses. Present outlook for sorghum is for a stable production from a decreasing area.

Rice-sorghum rotations

Apart from two exceptions, sorghum is seldom sown on irrigated paddy fields in India, in either the rainy or dry seasons. These exceptions are small plantings of irrigated sorghum for green fodder for domestic use, primarily for milk animals, and years when rains are late or fail (mainly in tank irrigated areas in south India) and sorghum is sown in lieu of paddy to provide an emergency food crop. In areas where dry season irrigation is available, fields are either in continuous rice or rotated between rice (rainy season) and high value food or industrial crops - groundnut, sunflower, vegetables, finger millet - (dry season); or in multiple year rotations of rice and crops such as sugar cane or mulberry. Sorghum is too low value a crop to compete for irrigated land in almost all areas in south; the requirement for sorghum grain and fodder will continue to be met almost exclusively from dryland cropping in the rainy season.

Legumes in rice- and wheat-based cropping systems of Asia - Interests and activities of ICRISAT's Legumes Program

C. Johansen
International Crops Research Institute for the Semi-Arid Tropics

Introduction

- Normal cropping systems for mandate legumes in Asia often involve rotation with rice or wheat, e.g.,:
  - rice-chickpea in sub-tropical S. Asia
  - rice-groundnut in SE Asia
  - SD pigeonpea-wheat in N. India

- Greater use of legumes key to reversing production decline + environmental damage of continuous cereal (or non-legume) systems

- Positive role of legumes in cropping systems well established (from Roman times!)
  - BNF inputs
  - other soil chemical benefits
    - e.g., root exudates - P release
    - deep and prolific rooting - nutrient cycling
    - nutrients in OM held in mineralizable form
  - soil physical benefits - thru OM and root activity - e.g., gives improved infiltration and WHC
  - soil biological benefits
    - breaks disease and pest cycles
    - stimulates mycorrhizal activity
  - production of high quality (e.g., protein, Ca) food feed and fodder as part of cropping system output.

- Challenge - how to increase use of legumes by rice and wheat farmers - must convince of economic and sustainability benefits (need integration with socio-economic factors).

- Purpose of presentation

  - indicate past and present LP* research relevant to RBCS or WBCS
  - indicate future research needs for ecoregional cooperative research that can be participated in by LP*

LEGUMES IN RBCS

- Understanding legume adaptation in rice growing areas
  - agroclim./GIS analysis and crop modeling (RMP lead)
  - multilocation trials

- Development of short-duration varieties of PP, CP & GN to better fit cropping windows and short periods of residual soil moisture. Also associated traits such as limited period of seed dormancy in GN

- Late sowing problems

  - less env. sensitive genotypes
    - Cold - CP, GN, PP
    - Heat - CP
    - Photoperiod - PP

  - agronomic options, e.g., increase population, fertilizer, irrig., etc.

- Ecology of legume pests & diseases in RBCS

- Disease and pest resistant legume genotypes for RBCS

- IP((&DI)M in RBCS

- Establishment of legumes in rice fallows

  - genetic
    - seed characters
    - early growth vigor
    - waterlogging tolerance
  - management - sowing techniques and timing

- Drought resistant genotypes and traits (e.g., rooting characs)

  - GGLDRN

- Cold tolerance for sub-tropics e.g., cold tol. of podset CP

*many topics involve collab. with ICRISAT's RMP

- Enhancing legume BNF contributions to RBCS

  - development of Nfix measurement techniques, e.g., ^{15}N nat. abundance, non-nod. controls
  - *Rhizobium* production and inoculation methodology - esp. for tropics and RBCS
  - host plant selection for improved BNF
  - measurement of residual affects of legume N.
  - quantification and modeling of N cycle, esp. Nfix aspects
  - AWGBNFL

- Integrated nutrient management aspects (besides N)

  - root quantification and modeling
  - role of root exudates
  - diagnosis of nutrient imbalances

- Adaptation to adverse soil conditions

  - waterlogging (PP)
  - salinity
  - acidity - WGASTGL

LEGUMES IN WBCS

- SDPP - wheat rotation

  - improved SD (and ESD) varieties
  - quantification of legume N benefits

- CP/wheat intercropping

CONSIDERATIONS FOR ENHANCING ECOREGIONAL APPROACH

- Need classification system for rice fallow soils (vs. soil properties relevant only to rice cultivation).

- Need to change rice/wheat crop characteristics to fit legume component (rather than just adjust legumes to cereal characs.) e.g., SD rice to allow earlier legume sowing.

- Although mandate currently restricts LP to CP, PP, and GN, also expertise on other relevant legumes.

- LP using OFAR approach for research priority setting and rational devolution/ allocation of research tasks (incl. strategic/basic) as well as catalyzing impact.

Rice-legume and rice-cereal cropping systems – issues for future research

C.L.L. Gowda, A. Ramakrishna, O.P. Rupela and N.K. Awadhwal
International Crops Research Institute for the Semi-Arid Tropics

Introduction

Rice is an important staple food crop in Asia which accounts for 90% of world production. South and Southeast Asia have 81 m ha under rice, of which only 30% of cropped land is irrigated and double cropped (sometimes triple cropped). With the increase in population and a steady decline in average farm size, there is an increasing demand for producing more food from existing land. Thus, the prevailing practice of monocropping rice and then leaving the fields fallow after rice harvest is disastrous because of its inability to meet the increasing food demand. In most fields after rice harvest, there is water in the soil profile sufficient enough to grow an upland crop provided the crop is established and the roots strike the moist sub-soil profile. Although, researchers and policy makers are looking increasingly to rice and rice-based cropping systems for the extra food that they need now and shall need more possibly in future, care need to be exercised to ensure sustainable levels of crop production by proper crop rotation and related resource management options.

Rice ecosystems

There are four major rice ecosystems in Asia namely: (a) rainfed upland (b) rainfed lowland (c) irrigated lowlands, and (d) deepwater rice.

(a) Rainfed upland ecosystem:

- mostly used by poor subsistence farmers in the tropics, and offers most difficult challenge to sustainability.
- some upland soils support a single crop of rice but most areas can be planted to more than one dryland crop (Ultisol, Alfisol).
- mixed, relay, and sequential cropping of upland rice is the common cropping practice.

- mostly acid soils, pose considerable difficulties to grain legume cultivation.

- common cropping patterns are:

  rice-maize
  maize+rice-maize
  cassava+maize+rice-legume
  rice-maize/groundnut
  rice+pigeonpea
  rice-chickpea

(b) Rainfed lowland ecosystem:

It has four rainfall regimes:

- pre-monsoon moist season: Upland catch crops are being cultivated. The major production constraints are drought and flooding.

- wet monsoon season: rice is the main crop.

- post-monsoon moistseason: Upland crops are grown with residual soil moisture or with limited irrigation. Production constraints noticed are excess moisture at crop establishment and drought stress at later growth stages.

- dry season: Fields are usually kept fallow, but some cropping may occur depending on irrigation water availability.

- common cropping patterns found in these systems are:

  rice-fallow
  rice-rice
  maize (or legumes)-rice
  rice-wheat
  rice-legumes (chickpea, lentil, mung bean, urdbean, cowpea)
  rice-groundnut
  groundnut-rice-groundnut
  rice-wheat-maize

(c) Irrigated lowlands:

Double cropping of rice is most prevailing practice. Depending on availability of water, other economically important crops such as wheat, tobacco, garlic, onion etc. are being grown as a third crop.

(d) Deepwater ecosystem:

- very little scope exists for other crops than rice.
- in the fringes of deepwater areas an upland crop can be taken in the dry season or in the pre-monsoon season.
- risks of flooding and crop failures are high.
- limited options for effective soil or crop management.

Importance of legumes in Rice-based cropping systems (RBCS)

Legumes are usually grown before or after rice because of:

- insufficient availability of water to support second season rice cropping,
- cold temperatures unsuitable for rice cultivation (winter crops, including legumes can be grown),
- breaking of disease and pest cycles,
- allowing soil to be oxidized,
- legumes are economically attractive and,
- legumes improve and maintain soil health (BNF and addition of organic matter).

Role of legumes in sustainable production systems

In many areas rice-rice, rice-wheat, rice-barley, maize-rice, cassava+maize+rice, and rice-safflower rotations are common. All these systems are exhaustive and are apparently unsustainable in the long run. Recent studies have indicated decline in production of both rice and wheat in a rice-wheat rotation system. Introducing legumes (either for grain, green manure, or both) would be beneficial in these systems.

Ability of legumes to fix atmospheric N_2 for their own use and beneficial residual effects on the succeeding cereal crops have been documented extensively. Biological Nitrogen Fixation (BNF) by legumes can be increased and/or optimized by proper crop husbandry practices viz.,

- Optimum soil temperatures (e.g., adjusting sowing time to have ambient temperature close to optimum BNF or selection of temperature tolerant strains).

- Optimum soil moisture at early growth stages of crop.

- Nitrogen status of the soil after cereal harvest since high soil N_2 suppress the nodule activity and BNF. Fertilizer management (quantity and time of application) of the cereal component, addition of organic matter soon after cereal crop harvest and selection of legume species having high nodulation and BNF help enhance the nitrogen fixation by legumes for larger residual effect on following crops and improvement in soil fertility.

Constraints to crop production in RBCS

Growing upland crops before or after rice offers more challenges than any other cropping system because optimum soil physical conditions for rice and upland crops differ substantially. Cropping sequences that include rice and upland crops therefore require special management.

(a) Soil constraints:

- The soil becomes hard and compact after the rice harvest resulting in increased bulk density, decreased infiltration rate and aeration. Rice fields also offer high impedance to root growth and development of upland crops.

- Poor soil physical conditions impose limitations to the process of seed germination, seedling emergence, root growth and development.

- Puddling destroys soil structure, decreases large pores and increases small pores in the surface layer. Changing soil porosity influences the diffusion rate of nutrient ions to plant roots, which may be of major importance for P nutrition.

- Rice soils have very little humus and low organic matter content. Consequently the water holding capacity is considerably lower.

- Continuous standing water and consequent anaerobic conditions lead to the production of phytotoxic compounds, reduced numbers of favourable microorganisms and micronutrient deficiencies.

(b) Agronomic constraints:

- Time of sowing is crucial under receding soil moisture conditions. Slow water loss from puddled soil limits early seedbed preparation and establishment of upland crops.

- Seeding depth in relation to precipitation and moist zone of soil is another important consideration in growing upland crops in rice fields.

- Inadequate and delayed crop stand establishment.

- Low hydraulic conductivity of rice soils inhibit vertical water movement. When field is flood or furrow irrigated a temporary perched water table develops and remains saturated for days after irrigation leading to upland crop root injury.

- Low phosphatic availability of the rice fields inhibit vegetative growth (both shoot and root growth) of upland crops.

- End season drought and photoperiod sensitivity.

Suggested areas for collaborative research in RBCS

Some possible areas for collaborative research in RBCS are:

- Delineation of areas (using GIS) with different cropping patterns in various RBCS.

- Delineation of agroecological zones with length of growing season combined with soil types (for identifying crops and cultivars that mature approximately within the growing season).

- Soil structure (physical factors that constrain establishment and production of non-rice crop)

- Nutrient management

- BNF management (including host selection and residual effect studies)

- Crop establishment, and crop growth (tillage, time of sowing, seed placement, plant density, crop geometry, weed control, fertilizer use, water management, residue management, choice of crops and cultivars, etc).

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