Summary Report on the Program Planning Workshop
Decision Aids for Integrated Soil Nutrient Management Project
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INTRODUCTION

During initial months after project funds became available, teams of project members traveled to Costa Rica, Mali and Philippines to select intensive testing sites in conjunction with host-country collaborators. Travel events, U.S. team-members and host-country institutions are listed in Table 1. A separate report is available for each of these trips (Osmond et al., 1997ab; Reid et al., 1997). Intensive testing sites will be used, whenever possible, for team activities in developmental research and evaluation of the decision support systems for integrated soil nutrient management (IntDSS).

Table 1. Travel dates, U.S. team composition and host-country collaborating institutions for travels to select project intensive testing sites in Africa, Asia and Latin America.

LOCATION	**TRAVEL DATES**	**U.S. TEAM**	**HOST-COUNTRY INSTITUTION**
Sarapiqui, Costa Rica	July 13-19, 1997	Osmond, Reid, Robotham, Smith, Smyth, Yost	Center for Agricultural Research/University of Costa Rica (UCR)
Cagayan, Luzon, Philippines	August 13-21, 1997	Osmond, Reid, Yost	Philippine Rice Research Institute (PhilRice)/International Rice Research Institute (IRRI)
Cinzana, Mali	September 25 - October 1, 1997	Reid, Smith, Smyth, Yost	Institute d'Economie Rurale (IER)

As a follow-up to the initial visits to and selection of intensive testing sites, our project's year 1 activities included a planning workshop for all U.S. team-members and representatives of each of the intensive testing sites (original plans also included attendance by participants of the project's extensive evaluation network, but the year-1 budget cut of $83,333 eliminated funds to support their travel and per diem). Objectives of the workshop were to:

- acquaint all project participants with agricultural practices, socio-economic conditions and natural resource characteristics of each intensive testing site; and
- jointly refine our project's 5-year plan of research and outreach activities to ensure the particular nutrient constraints at each site were properly addressed.

This workshop marks the first time in all project development history (pre-proposal, proposal and revised proposal) and early implementation activities when all members gathered for a joint meeting. Prior activities involved meetings of project coordinators or travel by a small group of team-members, complemented by volumes of mail correspondence.

Workshop participants are listed in Appendix 1. The workshop was attended by two representatives each from intensive testing sites in Costa Rica, Mali and Philippines, and 15 project-members from Cornell, Hawaii, N.C. State and Texas A&M universities. Only two project-members from U.S. universities were unable to attend the workshop. Meeting venue on the campus of the University of Hawaii at Manoa benefitted the project planning process through participation and contributions by the SM-CRSP Management Entity and a representative from the CRSP's NiFTAL project.

Program for the 3-day workshop is listed in Appendix 2. The program was organized to inform the group, through presentations in plenary sessions, of current developments and plans for various project components. Each plenary session was complemented by small-group discussions with subsequent reports from each group and discussion of these reports by all workshop participants. Moderators, reporters and participants in each group discussion are listed in Appendix 3. The three major project components addressed in plenary/group-discussion format were:

- characteristics of the intensive testing sites in Costa Rica, Mali and Philippines;
- knowledge gaps and information needs of the acidity, N and P decision support system components; and
- design, assembly and information needs for the integrated decision support system for acidity, N and P.

This program structure was intended to elicit exchange of ideas between individuals on their assigned tasks, while also enhancing each individual's awareness of how their particular assigned tasks will contribute to eventual development of decision support system products targeted by this project.

The following section of this report (Characterization of Intensive Testing Sites) contains the full presentations delivered at the workshop by host-country representatives characterizing each of the three intensive testing sites. Group discussions are summarized in a separate and succeeding section along with a description of project actions to be taken as a result of the workshop.

Trip Report References:

Osmond, D., S. Reid, M. Robotham, F. Smith, J. Smyth and R. Yost. 1997a. Report on trip to Costa Rica, July 13-19, 1997. USAID Grant No. LAG-G-00-97-00002-00. SM-CRSP IntDSS Project. 8p.

Osmond, D., S. Reid and R. Yost. 1997b. Report on trip to Philippines, August 13-21, 1997. USAID Grant No. LAG-G-00-97-00002-00. SM-CRSP IntDSS Project. 9p.

Reid, S., F. Smith, J. Smyth and R. Yost. 1997. Report on trip to Senegal and Mali, September 25 - October 1, 1997. USAID Grant No. LAG-G-00-97-00002-00. SM-CRSP IntDSS Project. 9p.

CHARACTERIZATION OF INTENSIVE TESTING SITES FOR THE SOIL MANAGEMENT CRSP'S INTDSS PROJECT

LAND USE MANAGEMENT AND POLICY IN CENTRAL AMERICA WITH SPECIAL REFERENCE TO THE ATLANTIC ZONE OF COSTA RICA

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INTRODUCTION

Central America is a small bridge that links North and South America, and relies on the export of agricultural products to generate foreign income. The geographical position of the region favors trading operations since the distance to international markets is short. This does not imply a low transportation cost because the volume of exports and imports with major trade partners is relatively small.

The region is a "price taker" and marketing activities thrive in an unreliable and heavily conditioned scenario. Although politically independent, the region is economically dependent and many political or economical decisions are the result of the best compromises attainable. Even for traditional crops like coffee and bananas, international trade agreements signed or agreed are in dispute. Despite free market policies wherein international activities should occur, for example, countries like Costa Rica are facing pressures from U.S. investors against the agreement between this country and the European Economic Community. Likewise, under the structural adjustment programs guided by the International Monetary Fund and the World Bank, the region that used to be self sufficient in food became a net importer of grains (Hansen, 1994) in a world claiming for sustainable development.

Taking advantage of international opportunities for the region, like the Caribbean Basin Initiative, the so called "market windows" and the recent economic reforms, allowed for a diversification of the agricultural sector by exporting non-traditional crops including the heart of palm. Many of the new activities require high inputs and capital investments, resulting in minimal participation of small farmers in this endeavor. New activities such as ecotourism and agroindustry arose in the last decade contributing to the diversification of the economy, but competing with agricultural activities for labor and land. Within this context, some internal adjustments are permanently needed to overcome negative social effects. In doing so, the authorities must avoid wrong macroeconomic policies and the generation of new trade distortion policies. Actually, all of this happens in an international scenario that changes at an accelerated rate.

Recent events in the region includes the meetings for the Central American Alliance for Sustainable Development (IICA, 1994). This agreement refers to the social, economic, environmental, and political changes the region have to undertake to evolve as a unit with more competitive characteristics. In addition, bilateral and multilateral agreements are on the table (Tuxtla-Gutiérrez I and II), trying to strengthen relations of the region with Mexico.

PHYSICAL, SOCIO-ECONOMIC, AND POLITICAL CONDITIONS OF CENTRAL AMERICA

Comprehensive reviews of Central American geographical characteristics can be found in FAO/UNESCO (1976), Leonard (1986), and Richters (1995). In summary, the isthmus stretches from latitudes 7°15' to 18°00' north covering an area of 489,000 km. The region is mountainous (more than 60% of the land with slopes over 12%), with very active volcanic structures and elevations ranging from sea level to 4000 m. The climatic conditions of the region reveals an almost always wet area on the Caribbean side (less than 1 month dry), an area with a distinctive dry season (4-6 dry months) along the Pacific coast, and a zone with short dry seasons in the central mountains and valleys. This altitudinal gradient largely determines ambient temperature which ranges from 0ºC at higher elevations to more than 24ºC at sea level. The predominant life zones in Central America includes the premontane moist forest, the tropical moist forest, and the premontane wet forest, with minor areas of premontane thorn woodlands and premontane dry forest.

More than 200 different soil associations are found in the region, including soils that classify mainly as Inceptisols, Andisols, Entisols, Alfisols, Ultisols, Mollisols and Vertisols. According to Beets (1990) and Higgins *et al.* (1984) the major soil limiting constrains to agricultural production in the region are drought, soil depth, mineral deficiencies, poor drainage, sandy textures, and 2:1 clays. This general set up is capable to support with restrictions most of the actual population of the region (Higgins *et al*., 1984), with special considerations to under use and abuse of the available resources (Vargas, 1992). According to various sources (Plath, 1964; Vargas, 1992; Leonard, 1986, and Carter, 1991), 44% of the region has agricultural potential, 36% is suitable for forest, and 36% is suitable for pastures. Land distribution is skewed since 6% of the farms occupy more than 60% of the territory (Luiselli, 1989); this leads to changes in land taxation grounds to minimize the problem (Celis and Alvarado, 1994).

In recent publications (Bulmer, 1989; INCAE, 1993), most of the parameters of Central America were considered based on the socio-economic and political situations since 1920 and the recent ideas of sustainable development (sustainability indexes of 19.1 for Costa Rica to -18.4 for Panama). This information together with data from BID (1994), Kaimowitz (1992), Lok (1993), Pomareda (1994), Alvarado (1995), and the ‘Federación Internacional de Sociedades de la Cruz Roja y la Media Luna Roja’ (1995) illustrated the uneven situation among the different countries in the region. Despite changes towards democratic governments during the last decade, Guatemala and El Salvador maintain armed forces with over 50,000 soldiers, Nicaragua and Honduras with over 20,000, and Panama and Costa Rica with a police force of around 10,000 each (Cordero and Zeledón, 1994).

In terms of population and ethnics, there are almost 32 million inhabitants in Central America including caucasians, native indians (15% of total), afro-caribeños and their mixtures, with a per capita income of US$1,455. On average, 45% of the total population is rural but around 40% of the economically active population is engaged in agricultural activities. For the period 1990-1993 over 800,000 inhabitants/year were living in their native countries and more than 100,000 were refugees in other countries; natural disasters accounted for almost 5,000 deaths/year and 350,000 lived in shelters.

In terms of human development indicators Costa Rica ranks high (0.848), followed by Panama (0.731) and the remaining countries with values below 0.498. According to Luiselli (1989), up to 1984 most of the countries exported mainly traditional crops such as coffee, bananas, cotton, and beef. Since 1980, however, non-traditional crops (fruits, vegetables, nuts, spices, roots and tubers, flowers, ornamentals) increased their share to the GDP from US$181 million in 1980 to US$325 million by 1989 (Kaimowitz, 1992). Major importers of Central America products are the U.S. and Europe, but there is an increasing intra regional trade that accounted for US$1,134 million in 1992, out of a total of US$9,965 million.

GENERAL ASPECTS OF THE ECONOMY AND NATURAL RESOURCES OF COSTA RICA

Alvarado and Monge (1997) described the agricultural sector of Costa Rica as engaging about 1.1 million people, or about 45.5% of total population. It holds the largest share at 22% of the country's GDP, thus forming the foundation of the Costa Rican economy.

Costa Rica recorded a sluggish or negative GDP which is attributed to the downswing in agricultural production that sustained the country's domestic economy for many years. The downward trend was notable especially for export crops such as bananas, cacao and sugar cane, wherein production dropped sharply owing to the fluctuations in international market prices.

Since the country lacks important amounts of natural resources and has few export items that can substitute for farm produce, its domestic economy depends heavily on agriculture. The socio-economic condition in the country is therefore influenced directly by the trends in agricultural production.

The government of Costa Rica has changed the economical development model through time, one of which is the so called 'Agricultura de Cambio' (Agriculture for Change) in 1986. The new agricultural development plan is summarized in the following five items:

1. To increase basic food products and food supply depending on the taste and income of the consumers.
2. To increase agricultural products for export and improve productivity.
3. To develop and increase new agricultural products for export.
4. To promote provision and registration of agricultural land for landless farmers and to support services for small-scale farmers.
5. To increase employment opportunities and farmer's income in the agricultural sector.

The new agricultural development plan aims to select and introduce new agricultural crops for export and to increase traditional agricultural products. This is a long term plan, taking a separate approach in each of six regions (Chorotega, Pacífico Central, Brunca, Central, Huetar Norte and Huetar Atlántica) to suit the specific local characteristics. The development regions and crops covered by the agricultural development plan are as follows:

REGION	CROPS
Chorotega	soybean, cotton, sunflower, maize, fruit, livestock.
Pacifico Central	fruit, oil-palm, soybean, livestock, fish
Brunca	oil- palm, cacao, fruit, soybean, livestock
Central	vegetables, tobacco, industrial crops
Huetar Norte	cacao, macadamia, fruit, livestock
Huetar Atlantica	banana, cacao, plantain, coconuts, peach palm, macadamia, livestock

THE ATLANTIC ZONE OF COSTA RICA

The major physiographic features of the northern part of this region were first studied by Nuhn and Pérez (1967), and recently re-evaluated by Stoorvogel and Eppink (1995). Detailed information on the social aspects affecting the development of the Atlantic Zone or some subregions can be found in Carvajal (1989), JICA (1988), and Jansen *et al.* (1996). The region is relatively flat (> 85% is under 100 m elevation above sea level) but includes large environmental differences. The area belongs to the tropical rainforest climate with annual rainfall of 3,000 to 5,000 mm. It is perhumid but tends to dry out towards the south-west side. Major geomorphic units include alluvial deposits (63.1%), mountains to the south (24.5%), and coastal barriers and bogs (11.3%). Four major soil units cover most of the Atlantic Region:

1. old, highly weathered, clayey, well drained soils (Oxisols, Ultisols, and related oxic subgroups of Inceptisols);
2. recent, well drained soils developed from volcanic ash (Andisols and Inceptisols);
3. young poorly drained soils developed from fine sediments of calcareous origin (mainly Eutropepts); and
4. organic soils (Tropohemist).

Most of the soils are deep and without significant amounts of stones or rocks, but high water tables and the presence of buried coral reefs (particularly in the southern part) limit root development. Excluding the Histosols, more than 50% of the soils present a high fertility status. Only 20% present low fertility due to coarse textures, low CEC, and low pH values. Around 30% of the region is never flooded, less than 5% of the region is subject of flooding once every 20 years, whereas the remaining of the lowlands are flooded with frequencies as high as twice a year.

In socio-economic terms, colonization of the region began around 1700, with repetitive efforts in different periods. In terms of development, the region can be subdivided in four periods:

1. the first banana expansion from 1874 to 1936;
2. the abandonment of banana plantations and the regional crisis (1936-1956);
3. reactivation of the banana industry and the State-directed development programs (1956-1984); and
4. the banana boom between 1984 and 1992.

In general, the development of the region was the result of the banana (transnational) interests up to 1956, with changes on colonization programs and infrastructure development since that time. However, banana plantations ownership by transnationals declined from 96% during 1947 to 57% in 1976. By 1992, almost 10% of the Atlantic Zone was planted with bananas, with an increment in area from 21,278 ha in 1984 to 44,187 ha in 1992. This in time lead to the definition of three major economic (development) regions:

1. the Pococí region (including Guácimo and Siquirres Districts of the Limon Province, and the Horquetas-Sarapiquí District of the Province of Heredia) with banana activities combined with cattle operations and the production of grains such as rice;
2. the Central District of Limon, including Matina and areas along the SAOPIN highway with less agricultural development than Pococí, but a lot more infrastructure and services (most of the tertiary sector lies in this unit); and
3. the Talamanca District with some new banana developments and a very primitive production systems based on roots and tubers, plantains and cacao plantations.

In general, two cropping seasons coexist, the planting of roots and tubers, maize and beans in September-October and the planting of rice in April-May, with perennial crops and pastures planted all year around.

A large amount of the people in and around Limon are "afrocaribeños" or people of Jamaican origin that live along the Caribbean Coast of Central America since they first arrived in 1872. Because of difficulties in transportation and the lack of government development efforts prior to 1956, this population dominated in the region. However, immigrants from other parts of the country as well as from Central America are very important at present, particularly in the banana expansion territories. Despite the fact that most of the trading activities of Costa Rica take place through the port of Limon, all refinery for the country occurs in the Atlantic Region, large amounts of foreign income comes from the banana industry in this zone, and large new tourism operations are under way in the Tortuguero, Gandoca-Manzanillo, and Cahuita National Parks, sustainability indices in a recent survey of the region indicated the lowest country ranking in productivity, equitability, resilience and stability. During the period 1972 to 1985, 129 of the 202 union strikes in the country (64% of the total) were concentrated in the Atlantic Region.

RESEARCH SITE CHARACTERIZATION

Under the present research program, the typical features of the Costa Rica research site consist of the following:

- A humid tropical climate with a rainfall surplus over evaporation of about 3000 mm, distributed over all 12 months of the year;
- Soils of volcanic origin;
- Recent and ongoing colonization and related rapid deforestation; and
- Strong influence of (multi)national companies oriented towards export of bananas and other agricultural products.

Objectives

The general objective of the work plan is two fold:

1. To execute a multidisciplinary research program; and
2. To disseminate research results to the broadest possible audience and support agricultural development activities in the study region.

On the basis of the approved research project the following immediate objectives are formulated:

- Development of tools for the analysis and planning of ecological and economical sustainable land use; and

- Testing of alternative scenarios for (sub) regions of the Atlantic Zone in Costa Rica.

The primary tools to be developed and tested are a combination of modeling, experimentation and multiple goal planning, resulting in alternative scenarios and computer decision support systems. By its nature, this research implies a multi- and inter-disciplinary approach.

Target Groups

As the research program is oriented towards economically feasible and ecologically sustainable land use, both on a small scale and a larger regional scale, the audience that can make use of the results is found at corresponding levels.

At the small scale farm level the target group is found in individual farmers, entrepreneurs specialized in specific crops as well as extension services and farmers groups. Examples of this audience and how they are reached are the following:

- Field experiments regarding sustainable fertilizer applications are conducted in farmers fields, the results are directly discussed with the cooperating farmer.
- The same accounts for experiments conducted at entrepreneurs specialized in certain crops.
- Presently non traditional crops for export are marketed through cooperatives of small producers. Cooperatives are also active in forestry since incentives for forest management or reforestation are often only granted to organized farmers. Marketing studies and forestry studies are to be made in cooperation with these cooperatives. Results will be discussed with these farmers groups.

At the (sub) regional level the target group consists of national, regional and private organizations engaged in agricultural development.

- SEPSA, the planning division of the ministry of agriculture is interested in the multiple goal planning model for regional land use.
- The Atlantic Zone division of MIDEPLAN (Ministry of Planning) is presently cooperating in collecting information and it will participate actively in the formulation of development scenarios to be tested.
- CORBANA, the private institute that not only supports national banana producers, but also promotes (commercial) diversification of agricultural production, supports the research program with laboratory and experimental facilities in their test farm. The expert systems for crops are of direct interest of this institution.

Agricultural economy

According to the results of a farm management survey the small-scale farmers, making up 80% of all farm households, find it difficult to make ends meet with only agricultural revenue. Many farmers, therefore, take jobs on banana plantations, etc. Their non-agricultural income accounts for about 50% of their total income.

Agricultural extension Services

Agricultural extension services are offered by the Ministry of Agriculture and Livestock (MAG) to the existing farm households, and by the Agricultural Land Development Institute (IDA) to new settlers. Neither authority is able to provide services to all farms. Both authorities are prevented from providing the services to all farm households because of the shortage of extension workers. Farmers in the new settlement areas are given more intensive extension services than those in the existing farmland areas.

Agricultural marketing

Bananas are exported to the U.S. and Europe through an exclusive marketing route. Tuber crops, on the other hand, are exported to the U.S. by trading companies operating in the area. The export volume of tuber crops, though negligible at the present time, is steadily increasing each year. Considering the number of Spanish immigrants in the U.S., the demand for tuber crops is expected to increase considerably. The other crops are generally collected by brokers and sent mainly to San Jose because no large markets or processing facilities are found in or near the study area.

Settlement

Settlement in the area has been promoted by IDA since 1965. By 1984, farmers had completely settled on area of 9,930 ha (1,127 farm households). Each household has purchased 8.8 ha of farmland on the average. No other settlement is planned at present in the area.

Farm villages

The villages in the area are of street-side type (10%), colony type (25%) or scattered type (65%). The reason for the greater portion of scattered villages is that settled farmers are obligated to live on or near their respective farmland. No utilities are available to the of scattered type villages. Each farmhouse depends on a shallow well for its drinking water, which is potentially polluted according to tests conducted at the site. This water is, therefore, dangerous to drink without boiling. Sewerage systems are also lacking, adversely affecting the quality of the water in the wells.

Land consolidation

The farmland in the area is not substantially equipped with drainage channels or farm roads except in the banana plantations. In the latest settlement areas, however, roads are constructed by IDA and the farmlands are arranged to face these roads, but such areas are only about 700 ha in total according to the field survey.

Social infrastructure

The social infrastructure in the area is not established yet. Roads leading to the banana plantations, though unpaved, are in comparatively good condition. Other roads, however, are left in such bad conditions that many of them are impassable during periods of high rainfall. The road conditions get worse further away from the national routes. There are few farm roads in general farmlands except for the banana plantations and some settlements. Schools, though not in short supply, are understaffed. About the only medical facilities are small public health centers built in major communities. The extension of telephone service to farming areas is very low, although a plan is under way for a telephone network. Electricity is the most-widely extended item of social infrastructure and is distributed to almost all farm households in all settlements.

Climate

The area belongs to the tropical rainforest with an annual rainfall of 3,520 mm. Rainfall is the least in March at about 140 mm, and greatest in December at about 460 mm. The average annual temperature is 25.3ºC. The lowest temperature is 15ºC registered in December.

Topography

The highest point in the area is 110 m and the lowest is about 0 m. Distribution of the area by elevation above sea level is as follows:

ELEVATION	AREA	PERCENT
	ha	
110 to 80 m	45	0.2
80 to 60 m	80	0.4
60 to 20 m	1,030	5.3
20 to 10 m	4,925	25.2
10 to 2 m	10,310	52.9
2 m or less	3,110	16.0
Total	19,500	100.0

Soil characteristics and classification

The soils in this region, roughly classified, comprise alluvial soils which are superior in chemical properties and fertility. They are therefore suitable for planting. Nevertheless, this advantage is not fully utilized due to the unsatisfactory drainage characteristics.

SOIL ORDER	AREA	PERCENT
	ha	
Entisol	7,808	36.3
Inceptisol	12,130	62.2
Ultisol	290	1.5
Total	19,500	100.0

According to the USDA method used in Costa Rica, the land was classified as follows, taking the drainage conditions into consideration. About 14,625 ha of land with classes I to V could be effectively used for agriculture in this region.

CLASSIFICATION	SUITABILITY FOR FIELD CROPS	AREA	
		ha	%
I	Highly suitable	---	---
II	Moderately suitable	9,925	50.9
III	Marginally suitable	620	3.2
IV	Suitable for perennials	4,080	20.9
V	Suitable for pasture and forest	---	---
VI	Only suitable for perennials & pasture	290	1.5
VII	Only suitable for rice & pasture	4,585	23.5
Total		19,500	100.0

AGRICULTURAL PRACTICES ON HEART OF PALM PLANTATIONS

Peach palm (*Bactris gasipaes* H.B.K., “Pejibaye”, “Pupunha”) is a native palm of Tropical America that bears large clusters of an edible fruit that is widely used in several distinctive ways. The exact origin of the pejibaye has not yet been established. In Central America the pejibaye appears to have been distributed by man, as it is well known and widely utilized in Panama, Costa Rica, and Nicaragua. Outside of the American continent the pejibaye is almost unknown. It is found in Jamaica, Trinidad, Cuba and Malaysia.

Pejibaye culture

This palm is adapted to a wide range of tropical conditions. In Costa Rica it is found from sea level to 1500 m elevation, but yields are reduced at elevations above 700 m. Its upper temperature limits are hard to define. High temperature does not restrict growth as long as moisture is sufficient.

The soil requirements for its establishment are not well defined. Pejibaye does best in rich alluvial deposits. In Brazil it is found on highly eroded and lateritic uplands as well as alluvial plains. In Costa Rica is produced on clay loam and occasionally pure clay soils. Although the palm is tolerant of infertile soil conditions, high productivity on such soil will be sustainable only if native soil fertility is supplemented with organic or inorganic nutrient additions.

Distribution in Costa Rica

Plantations of the palm exist in the Atlantic zone (Sarapiquí, Pococí and Siquirres), the Northern zone, and the South Pacific region for a total planted area of about 11,000 ha. At the site selected for the project at Sarapiquí in the Atlantic zone (in a town named “Horquetas”) DEMASA has planted 1500 ha and small farmers have 4500 ha, for a total of 6000 ha.

International demand for pejibaye palm heart in 1996 was 40,000,000 units. Costa Rica yield for the same year was only 30,000,000 palm hearts. With existing technology the current mean annual yield is 10,000 palm hearts ha^{-1} with the goal of reaching 15,000 units ha^{-1}.

Soil characteristics in present day plantations are low fertility and high levels of acidity. Due to the lack of scientific data, recommendation are based on field experience. The current fertilization program is as follows:

NUTRIENT	**ANNUAL RATES**
N	200-400 kg ha^{-1}
P_2O_5	50-100 kg ha^{-1}
K_2O	60-150 kg ha^{-1}
MgO	30-60 kg ha^{-1}
S	40-80 kg ha^{-1}
$CaCO_3$	0,5-2,0 t ha^{-1}

Nutrient accumulation in peach palm (Herrera, 1989).

PLANT PART	**N**	**P**	**K**	**Ca**	**Mg**
	kg ha^{-1}				
Trunk	28.0	4.8	31.0	4.7	3.9
Tender core	8.6	1.3	5.8	0.9	0.8
Whole plant	531.0	37.9	248.3	64.8	43.0

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THE INTENSIVE TESTING SITE OF CINZANA, MALI: CHARACTERISTICS AND PERSPECTIVES

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INTRODUCTION

Cinzana is located in the center of "agricultural Mali". The village is about 40 km from Segou, the capital of the state of Segou. Cinzana is the site of one of the research stations of the Institut d'Economie Rurale (IER). This decentralized station has the primary mandate to generate technologies which are technically sound, economically feasible, and socially acceptable by farmers of the Cinzana area. Research programs of the station are primarily focused on millet, sorghum, fonio, cowpea, agroforestry, farming systems, and the management of natural resources. The station is affiliated to the regional agronomic research center based in Niono (105 km from Segou). The infrastructural development of the station facilities has led to strong collaborative research programs between the station's staff and scientists of national and international research projects (ICRISAT, INTSORMIL, TropSoils, CIRAD, University of Mcguil in Canada, etc.).

The choice of the Cinzana area as a research site was based on the following characteristics of the area:

i. agriculture is essentially for food crops;
ii. the environment falls into both the semiarid and Sahel regions of West Africa;
iii. farmers are in most cases are resources-limited; and
iv. a wide range of the soil types found in the area.

Most of the research activities conducted in Mali by the former TropSoils project were implemented at the Cinzana station. These and other research activities have generated a knowledge base on natural resources, agricultural practices, and socio-economic conditions of the Cinzana area. All the above contribute to make the Cinzana area an excellent intensive testing site for both Mali and the Sahel region of West Africa.

NATURAL RESOURCES

Soils

Soils of the Cinzana area are all represented at the Cinzana station. Soils in the Cinzana station are distributed according to a toposequence with different soil positions or hillslope elements: summit, shoulder, backslope, footslope, and toeslope (Ruhe, 1960). Selected properties of the different soil positions are given in Table 1. The toeslope portion of the area extended over about 7 km to the Bai river, a major tributary of the Niger river. This type of toposequence or valley system of landscape is very common in Mali as well as in many other regions of West Africa (Ouattara, 1990). Soils of the Cinzana area are in most cases Paleustalfs (Takow et al., 1991).

Soils of semiarid and subhumid Mali and other regions of West Africa are generally weathered, commonly acid, low in organic matter content, poorly buffered, and characterized by

Table 1. Selected soil (0-15 cm) properties as influenced by soil position in the Cinzana toposequence.

SOIL POSITION	TOTAL SAND	TOTAL CLAY	ORGANIC MATTER	pH IN H_2O (1:2)	P	EXCHANGEABLE CATIONS					ECEC	AL + H SATUR.
						Ca	Mg	K	Na	Al		
	------------------%------------------				ug g^{-1}	------------------cmol (+) kg^{-1}------------------						%
Summit	92	4	0.2	5.2	7.4	0.6	0.2	0.1	0.01	0.19	1.1	18
Shoulder	93	3	0.2	6.4	17.9	1.4	0.2	0.1	0.02	0.00	1.7	0
Backslope	88	5	0.2	4.9	6.7	0.5	0.2	0.1	0.02	0.34	1.2	31
Footslope	81	14	0.4	5.1	8.1	0.8	0.3	0.3	0.03	0.34	1.8	19
Toeslope	54	36	1.0	5.3	8.8	5.3	2.4	0.6	0.04	0.02	8.4	<1

a dominance of kaolinite and sesquioxides (Juo and Fox, 1977; Wilding and Hossner, 1989; Takow et al., 1991; Manu et al., 1991; Doumbia et al., 1993). Phosphorus is the most deficient and plant growth limiting nutrient in these soils (Enwezor and Moore, 1966; Pichot and Roche, 1972; Poulain, 1976; Manu et al., 1991). Jones and Wild (1975) documented that P deficiency could be so acute that plant growth stopped once the seed reserve of P had been depleted.

Waters

The Cinzana area receives an annual mean rainfall of about 650 mm from May to October. About one-half of that rain falls in July-August, and rainfall intensity of 40 mm/hour is common in August. The Cinzana area is located on the banks of the Niger river and the Bani river, a major tributary of the Niger river. These two rivers are about 50 km apart. However, water from these rivers is not used for supplemental crop irrigation.

Vegetation

The natural vegetation of the Cinzana area can be stratified into three major types: trees, shrubs, and grasses (PIRL, 1988). Trees are dominated by *Vitellaria paradoxa* (sapotaceae), *Parkia biglobosa* (mimosaceae), *Bombax costatum* (bombacaeae), *Prosopis africana* (mimosaceae), *Sclerocarya birrea* (anacardiaceae), *Adansonia digitata* (bombacaceae), and *Balanites aegyptiaca* (zygophyllaceae). Each of these trees makes a substantial contribution to the local economy.

The shrub type of vegetation is dominated by *Guiera senegalensis* (combretaceae), *Combretum ghasalense* (combretaceae), and *Piliostigma reticulata* (ceasalpiniaceae). The grass type of vegetation is dominated by *Andropogon gayanus* (grass), *Combretum micranthum* (combretaceae), *Pennisetum pedicullatum* (grass), and *Eragrostis tremula* (grass).

Tilemsi Phosphate Rock

The Tilemsi Valley region of Mali contains large deposits of phosphate rock (Tilemsi PR). These deposits are estimated to be about 20 millions Mg (Truong et al., 1978). A fertilizer factory will be built at Markala (about 70 km from Cinzana) within the next 3 years. Tilemsi PR contains 12.22% P, 30.8% Ca, 0.21 % Mg, 0.04 % K, and 0.08 % Na (Truong et al., 1978). It has a medium solubility and can be directly used in crop production (Poulain, 1976; Truong et al., 1978; Thibout et al., 1980; Hellums et al., 1989; Doumbia et al., 1993). Dry matter yield, soil exchangeable Ca, soil pH, and Ca uptake increased with increasing rates of Tilemsi PR in a Bladen acid (pH 4.5) sandy loam (Hellums et al., 1989). In addition, the amount of exchangeable Al extracted was significantly reduced. Similarly, Tilemsi PR increased sorghum growth and yield, soil pH, soil exchangeable Ca and Mg, and reduced Al toxicity in Grossarenic and Plinthic Paleustalfs (pH 5.1) of the Cinzana Station (Doumbia et al., 1993).

SOCIO-ECONOMIC CONDITIONS

Cinzana, a County of 73 Villages

The Cinzana area or community consists of 73 villages, each headed by an elected chief. The entire area is directed by an administrator nominated by the Governor of the state of Segou. This administrator is based at the village of Cinzana. The size of the villages ranges from about 20 (village of Amartobougou) to 24000 people (village of Samine). The village of Cinzana has about 10000 people in about 150 family households.

Village Structure

Each of the villages consists of family households which are often distributed according to a clan or tribe structure. Major clans or tribes include Bambara (farmers), Noumou (blacksmiths), Fulani (shepherds), and Bozo (fishermen). This clan or tribe structure primarily follows the job distribution of the community. However, farming is practiced to some extent by each of the clans or tribes.

The land is free. Any land within the community boundary not in use can be used by any member of the community with the approval of the village council. Any land of a given family remains a possession of future generations of that family. Only the Malian government can take away land from a family for the purpose of general interests such as research station, constructions, etc.

Hunting and fishing are open to everyone, but subject to government regulations such as hunting permits and periods, endangered species restrictions, etc. In the same line, wood cutting and animal grazing on public land are free and open to anyone, but subject to government regulations. Most of these government regulations are very often not enforced.

Housing is simple and permanent. Construction materials include clay bricks, and sorghum and millet stems. These stems are removed from the field after leaves have been grazed by animals. This uses of cereal residues for housing construction and garden fencing are solutions to immediate problems the farmer faces. Farmers understand the effects of crop residues on the soil, but unless the above uses are satisfied by alternative means, the scope of cereal residues management seems remote.

Sales and purchases are mostly done during weekly markets of the area. Cinzana holds its market on Thursdays. Surrounding or neighboring villages have different market days. There are two schools for the entire Cinzana area or community. One of these schools is located at Cinzana, and holds classrooms up to the 9th grade.

Activities & Income

Agriculture in the Cinzana area is mostly for food crops. These include sorghum, millet, fonio, and cowpea. Peanut is grown in few cases for supplemental cash income. Forestry, through harvesting the fruits and leaves of several of the trees indicated above, makes a substantial contribution to the local economy. Livestock related activities are essentially on cattle and sheep. The meat market however is mostly for cattle. Fishing is in most case practiced by the tribe Bozo. This activity supplements the farming performed by the Bozo. Gardening is essentially limited to areas along river beds. In few cases gardening is promoted by the government or NGO's as a source income for women.

Art works are mostly blacksmith activities. These make an important local contribution to promoting farm equipment. Dealers or traders are often "middle men" between these different activities. They also bring to the area several supplies, agricultural inputs, and miscellaneous items. Unfortunately, these middle men often make more profit from agricultural produce than the farmers.

Farmers' Organizations

Farmers' organization in the area is limited to the "Ton Villageois", an association of farmers of the same village. There is one "Ton" in almost each village. The "Ton" is a sort of cooperative of farmers. Its objectives may vary from one village to the other. In general the "Ton" aims at promoting social, economic, and a cultural development of its members.

Agricultural Research and Extension

As stated earlier, Cinzana is the location of one of the stations of IER. This decentralized station has the primary mandate to generate technologies which are technically sound, economically feasible, and socially acceptable by farmers of the Cinzana area. Technology transfer and assistance to farmers of the Cinzana area are mostly done by the following structures:

i. PNVA - a governmental agricultural extension service in charge of technology transfer. It also promotes farmers' organizations;
ii. FIDA - a credit project (government controlled) in charge of loans for farm equipment and inputs;
iii. CAR - a training center (government owned) for young farmers; and
iv. AED - a project for promoting gardening for women.

NONGOVERNMENTAL ORGANIZATIONS

Few NGO's are also involved in promoting rural development in the Cinzana area. These include the following (Berlin, 1997):

i. Voisins Mondiaux - an international NGO promoting agriculture, food security, natural resource management, health, communication, management, and miscellaneous activities.
ii. Vision Mondiale - a baptist church NO involved in promoting education, agriculture, water quality, women, and development in general.

AGRICULTURAL PRACTICES

Cropping systems

Agriculture in the Cinzana area is dominated by dryland farming of cereal and legume crops whose growth and development are strictly rainfall dependent. Millet, sorghum, and fonio, are dominant cereals. These are grown on 91% of the farm land (Berlin, 1997). However, farmers whose production are below subsistence level use low input and early maturing crops such as fonio and voandzou to fill food shortage between seasons. Peanut, cowpea, and voandzou occupy 8% of the cropped area of the region. Recent investigations reported that 17% of the farmers are growing improved cowpea cultivars in the area (Berlin, 1997).

Depending on the toposequence, cropping systems are either millet based on sandy soils or sorghum based on heavier soils. Some of the dominant cropping systems of the area are indicated below:

i. Continuous cereal monoculture - in this system millet or sorghum is grown continuously for years (more than 20 years in some cases) on the same plot. Generally, fields under this cropping system may be either abandoned in the long run due to low yield level (low soil fertility) or used to grow other crops such as fonio or cowpea for soil fertility replenishment.
ii. Intercropping of cereals and legumes - a traditional cropping system in which farmers grow cereal as main crop along with a legume crop. The rationale of this system is to ensure land profitability. Yield objectives of the system is full yield from the main crop and an additional yield from the second crop.
iii. Cereal rotation with peanut - these rotations include millet-cowpea, sorghum-cowpea, millet-peanut, and sorghum-peanut.

Cultural Practices

The cultural practices are adapted to the socio-economic conditions of the area and may change from one crop to another. The major practices are:

i. Land clearing and burning - these preliminary activities start in May. They are preceded by cutting and uprooting of trees and shrubs of less economic importance in order to facilitate the performance of mechanized farm operations with oxen-drawn equipment. Field residues are burned in many cases or turned under.

ii. Land preparation - operations include no-tillage, plowing, pseudo-plowing, and ridging. The choice of the method depends on soil type, land configuration, time of the season, level of farm equipment, etc. No-tillage is usually done on any soil when the farmer is late or not equipped with appropriate tools. Pseudo-plowing is carried out on sandy soils. Due to soil hardiness and weak physical condition of traction animals, heavy soils are rarely prepared. Ridges and furrows as seedbeds are used to facilitate sowing and soil water management during seedling growth and development.

iii. Fertilizer application - manure or compost preparation/application is in most cases the only input for improving soil fertility. In fact, up to 73% of the households are applying manure or compost. In terms of application rates, larger rates are applied to fields located next to house compounds. For fields that are far, application rates are related to the level of farm equipment.

iv. Planting - manual or mechanized (animal drawn) sowing is usually done with the first rains. Optimal planting period for the area is from mid-June to the end of July. Irregularities in rainfall can lead to repeated plantings (gap filling) until the desired plant population is obtained. Seeds in 73% of the cases are treated with a fungicide-insecticide mixture (Berlin, 1997).

v. Weeding and bedding - weeding (in general the first weeding) is one of the major constraints to agricultural crop production in the area. The ownership of weeding equipment is critical to alleviating this constraint. Most fields are weeded once or twice in the season. Bedding is usually done at tillering or panicle initiation stages of sorghum/millet growth and development.

PERSPECTIVES

Sustainable Soil Management Activities

An on-farm activity is being initiated by IER structures on sustainable soil management. This project is being implemented in participatory approach with one farmer of the village of Cinzana (Saouty Toure,) and one farmer of the village of Dougouba (Lassana Djire,). Dougouba is about 55 mk from Cinzana. The objectives of this project are as follows:

i. Determine the fluxes of selected nutrients (nutrient balance) in cereal-based cropping systems; and

ii. Define low-input strategies to sustain the fertility of soils under permanent cereal cropping systems.

The project will be implemented in the following two phases:

i. Diagnostic phase to determine nutrient constraints to sustainable management of the fertility of soils under permanent cereal cropping systems; and

ii. Participatory activities to define strategies to sustain the fertility of these soils.

Decision Aids for Integrated Nutrient Management

Proposed activities in developmental research and outreach programs of this SM-CRSP project fit very well into those the above IER project. Developmental research activities of the SM-CRSP project would be implemented with two additional farmers in each of the villages of Cinzana and Dougouba. A full time technician would be hired at each of these two villages to monitor the activities. Outreach activities would be conducted with selected samples of the entire Cinzana area.

Budget for 1998

Specific needs for 1998, beside materials, supplies, travel and miscellaneous expenses, include 2 field technicians and support equipment such as a pH meter, spectrophotometer, and miscellaneous laboratory glassware. The estimated costs for these are indicated in Table 2.

Table 2. Budget in U.S. dollars for 1998 (estimated cost per year).

CATEGORY	1998
Salaries	10,000
Materials and Supplies	15,000
Support Equipment	15,000
Travel	10,000
Miscellaneous	10,000
Total	60,000

CONCLUSIONS

Most of the research activities conducted by the former TropSoils project were implemented at the Cinzana station. These and other research activities have allowed to generated a knowledge base on natural resources, agricultural practices, and socio-economic conditions of the Cinzana area. This knowledge base indicates that farming in the Cinzana area is mostly for food crops on soils which are generally weathered, commonly acid, low in organic matter content, poorly buffered, and characterized by a dominance of kaolinite and sesquioxides. Manure or compost preparation/application is in most cases the only input for improving soil fertility.

This knowledge base will be used in implementing developmental research and outreach activities of the new SM-CRSP project. The objectives of the new SM-CRSP project fit well into those of an on-going research/development activity (excess acidity, nutrient deficiencies, limited available soil water) initiated by IER in the Cinzana area.

It is strongly hoped that outputs and impacts of this collaborative project will significantly improve food security, reduce economic hardship, and provide more options to limited-resource farmers.

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PHILIPPINE REPORT:
CHARACTERISTICS OF THE UPLAND PRODUCTION SYSTEM

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Upland rice is defined as rice grown in rainfed, naturally well-drained soils with bunded or unbunded fields <u>without surface water accumulation</u> (Kush, 1984). There is no correlation between the upland ecosystem and the elevation of the growing environment. To remove the intuitive association of upland with higher elevation, Huke (1982) preferred to use the term dryland. <u>Dryland rice</u> as rice grown in fields that are not bunded, are prepared and seeded under dry conditions, and depend on rainfall for moisture (Huke, 1982).

UPLAND RICE DISTRIBUTION

Upland rice is grown in 10.5 million ha in Asia. Approximately 4 million ha of rice are grown on level to gently rolling fields. The remaining rice areas are situated on rolling topography to sloping mountains, with slopes in excess of 30%. In South Asia, most of the upland rice is planted in flat plains in the high plateau of India and Bangladesh and covers about 7 million ha.

In Southeast Asia, upland rice is grown on 4.6 million ha, or about 12% of the rice area (IRRI, 1995). Approximately 1.5 million ha are grown in subhumid hilly regions of southern China, northern Myanmar, northern Thailand, Laos, and Northern Vietnam. The remaining is planted in the humid tropics of Philippines, Malaysia, and Indonesia (Table 1). Upland rice-based cropping systems in Asia are diverse and upland rice is grown under both permanent and shifting cultivation systems.

In Asia, upland rice is primarily a subsistence crop. Due to the vulnerability of upland rice to biotic (weeds, blast, brown spots, stem borers, and nematodes) and abiotic stresses (drought and soil problems) and the low incomes of upland farmers, very few external inputs such as fertilizers are applied to upland rice (Table 2; Pandey, 1996).

UPLAND RICE AREAS IN THE PHILIPPINES

In 1976, upland rice comprised about 300,000 ha in the Philippines. The Southern Tagalog Region has the largest area of 98,000 ha distributed as follows:

Batangas -	33,000
Mindoro -	19,000
Cavite -	17,000
Quezon -	17,000
Palawan -	12,000

The second largest upland rice area is in the Western Mindanao area which is concentrated in Zamboanga del Sur (44,000 ha). The area planted to upland rice tends to decrease in the Philippines.

In 1994, there were about 150,000 ha for upland and this area is continuously decreasing. Reasons for the decline are:

- higher price of high-value crops such a fast-growing trees, mango, and vegetables; hence, rice is being replaced by other crops; and
- the Philippines government's Medium-term Agricultural Development Plan (MTADP);

Table 1. Distribution of rice crop area in Asia, by environment, 1991.

MAJOR CONSUMING AND PRODUCING COUNTRIES	TOTAL AREA	DISTRIBUTION IRRIGATED	RAINFED LOWLAND	FLOOD-PRONE	UPLAND
	1000 ha	--------------------% of rice area--------------------			
Bangladesh	10,245	22	47	23	8
Cambodia	1,910	8	48	42	8
China*	33,019	93	5	-	2
India	42,308	45	33	7	2
Indonesia	10,282	72	7	10	15
Japan	2,049	99	**	-	11
Korea, DPR	1,200	67	20	-	1
Korea, Rep	1,208	91	8	-	13
Lao PDR	557	2	61	-	1
Malaysia	691	66	21	1	37
Myanmar	4,575	18	52	24	12
Nepal	1,412	23	66	8	6
Pakistan	2,097	100	-	-	3
Philippines	3,425	61	35	2	-
Sri Lanka	791	37	53	3	2
Thailand	9,271	7	86	7	7
Vietnam	6,303	53	28	11	1
TOTAL	132,240	55	29	8	8

*including Taiwan province

** magnitude zero

Sources: FAO AGROSTAT, 1994, FAO, Rome; IRRI RICESTAT, 1994; World rice statistics, 1993-94.

Average upland rice yields have increased from about 1 t ha^{-1} in 1980 to 1.2 t ha^{-1} in 1986. In the Philippines, upland rice and other upland crops are generally grown in landscape sites where the soil moisture regime is not adequate for wetland rice culture. Upland fields, most of the time, have gentle to moderately undulating topography and are also in relatively leveled areas with good drainage. Upland rice soils include Entisols, Inceptisols, Mollisols, Vertisols, Alfisols, and Ultisols. In the region of Bicol, the soils are mainly rich volcanic ash and the properties are greatly influenced by the high content of allophane. Ultisols represents perhaps the most widespread and most problematic soil planted to upland rice in the Philippines (Hernandez et al., 1996).

Table 2. Characteristics of an upland rice production system, 1988 wet season.

CHARACTERISTIC	MEASUREMENTS
No. of farms	17
Yield (kg ha^{-1})	913
Farm size (ha)	1.1
Tenure (% renters)	40
Tractor adoption (%)	-
Thresher adoption (%)	-
Direct seeding (%)	100
Applied N (kg ha^{-1})	16
Applied P (kg ha^{-1})	-
Applied K (kg ha^{-1})	-
Labor (days ha^{-1})	73
Hired labor (%)	59
Rice cropping intensity	100
Total cropping intensity	140

Source: IRRI, 1995.

In 1993, the Philippine government through the Department of Agriculture started the implementation of the 5-yr (1993-1998) MTADP to enable farmers and fishers to increase their incomes and obtain for themselves a better quality of life. Using the key production area (KPA) development approach the program encourages farmers and fishers to produce specific crops, livestock, and fish products only in areas which have an advantage in producing such commodities. This program resulted in a significant reduction of areas devoted to upland rice and maize production. Before the implementation of the program the rice and maize areas totaled 2.5 million ha each.

The Department of Agriculture through the *Gintong Ani Program* (Golden Harvest), aims to concentrate rice and maize production in about 1.9 million ha (1.2 million for rice and 0.7 million for maize) identified as best suited for these crops. In the case of rice, the Department of Agriculture gives assistance to farmers in irrigated areas through:

- certified seed subsidy;
- construction of new and rehabilitation of` existing irrigation system; and
- making more credit available for farmers to buy inputs, postharvest equipment and facilities.

Another program under the MTADP is the Key Commercial Crops Development Program (KCCDP). Commercial crops refer to fruits, vegetables, plantation crops, root crops, legumes, spices, and ornamental crops that are of high value and are not intended for home consumption.

PHILRICE PRIORITIES FOR UPLAND RICE

Characteristics of upland rice varieties released since 1972 are described in Table 3. Variety IR 43, released in 1978, has the highest recorded average yield, with 3.5 t ha^{-1}. However, its growth duration is long (129 days) and its very short stature (77 cm) makes it susceptible to weeds. Variety UPLRi-5 has a very good plant stature, can compete with weeds, has good grain qualities, and is not susceptible to lodging. Variety UPLRi-7 has an average yield of 3.0 t ha^{-1}, matures earlier, has a shorter stature than UPLRi-5, and has a good medium-long slender grain shape. But, its brown hull is not appreciated by rice traders. Variety UPLRI-7 is moderately resistant to blast and tungro, moderately susceptible to bacterial blight and grassy stunt.

Upland rice varieties recommended to farmers in the Philippines by the National Seed Industry Council are listed in Table 4.

Table 3. Characteristics of upland rice varieties released from 1972 to 1990.

VARIETY	YIELD	GROWTH	HEIGHT	GRAIN SIZE[a]	MILLING
	kg ha^{-1}	days	cm		% recovery
C22	2182	128	108	M-L/S	66.5
IR 43	3525	129	77	M-L/S	-
IR 45	2511	131	100	M-L/S	-
UPLRi-3	2405	125	109	M-L/S	-
BPIRi16	2539	125	104	L/S	-
UPLRi-5	2678	120	117	L/S	67.4
UPLRi-7	3044	116	104	M-L/S	65.0
PSBRc 1	2392	121	104	L/S	64.2

[a] M=medium, L=long, S=short

The upland rice development program will focus on the development of upland rice varieties with stable yield (3.5 t ha-1), good grain quality, adaptation to specific agro-ecological upland conditions of the country, and traits such as early maturity, medium plant height, low tillering with more spikelets per panicle, and resistance to pests, lodging, and water stress. Since upland rice soils are mostly acidic and have low fertility, cultivars with superior grain quality and improved ability to extract nutrients and water from the subsoil will be developed.

Other issues concerning the sustainability of upland rice-based systems in acidic and low fertility soils, such as integrated pest management and integrated nutrient management must be investigated. It is envisioned that upland rice will remain an important component of the cropping systems in areas targeted for commercial crops. Farmers will continue planting upland rice as a source of food and use commercial crops to increase and diversify their sources of income (Hernandez et al., 1996).

CLIMATE AND SOILS IN THE INTENSIVE TESTING AREA

The Isabela region has two types of climate. Rainfall is moderate and more or less distributed throughout the year in Eastern Isabela including its coastal area. In Western Isabela dry and wet seasons are not very pronounced. It is relatively dry in the first half of the year and relatively wet during the second half. Rainfall is also moderate. The Isabela Region had the highest probability of the passage of tropical cyclones centers, with 40% of the typhoons that hit the country passing through the Region. This occurs from July to November.

Cagayan has three types of climate. The first type is characterized by two pronounced seasons: relatively dry from November to April and wet throughout the year. This is generally experienced in the Sta. Praxedes and Claveria area. The second type covers the biggest area of Cagayan, from Claveria to Sta. Teresita toward the East and to the general area of Tuguegarao to the South, and Tuao in the Southwest. The seasons are not very pronounced, but relatively dry from November to April and wet throughout the year. The third type is characterized by a more or less evenly distributed rainfall throughout the year. This type extends to the Sierra Madre Mountains and its foothills, including Gonzaga and Sta. Ana.

Selected properties for surface soil samples at the Hacienda San Antonio site are shown in Table 5. Characteristics of the site in IIagan, Isabela can be compared to soil characteristics of other acid, upland research sites in Asia shown in Table 6.

Table 4. Upland rice varieties recommended by the National Seed Industry Council to upland rice farmers in the Philippines.

VARIETY	**RELEASED**	**PARENT/ ORIGIN**	**GROWTH**	**AMYLOSE[a]**
	year		days	
Fortuna	1955	Pa Chiam/ Taiwan	133	I
Milfor 6	1955	Milketan/ Fortuna	-	-
Kinandang Puti	1955	Local variety	-	-
Palawan	1956	Local variety	130	I
Nagdami	1956	Local variety	-	-
Azucena	1956	Local variety	123	I
Pinulot	1957	Local variety	-	-
Mangarez	1959	Local variety	126	Low
Milpal 4	1959	Milfor 6/ Palawan	124	-
Dinalaga	1960	Local variety	127	I
Texas 317	1963	USA	-	-
HBDA-2	1963	Developed locally	-	-
Azomil 85	1963	Developed locally	-	-
C 18	1964	Developed locally	-	-
BPI 48	1965	Developed locally	-	-
Azoil 286	1967	Developed locally	-	-
C 22	1972	Tjeremas/ BPI-76/ Palawan/ Azucena	128	High
IR 43	1978	IR3055-3-17-1-3/IR 24	129	Low
IR 45	1978	IR1416-128-5/ IR1364-37-3- /IR824-1	131	High
UPLRi-3	1979	Malagkit sungsong/ IR512-E576	125	I
BPIRi-6	1979	BPI-121-407C12	125	I
UPLRi-5	1980	Sigadis/ BPI-76-1	120	I
UPLRi-7	1981	C22/IR226/C22/OS4	116	I
PSBRc 1 (Makiling)	1990	KN-1B-361-1-B-6/E425/IR22///BPI 76*9/Dawn	121	I

I = intermediate amylose content

Table 5. Selected properties for surface soil samples at Hacienda San Antonio, Ilagan, Isabela, Philippines.

	pH			ORG.	TOT.	BRAY 2	EXCHANGEABLE				EFF.	CBD-EXTRACT.			
LOCATION	**H_2O**	**$CaCl_2$**	**KCl**	**C**	**N**	**P**	**K**	**Ca**	**Mg**	**Al**	**CEC**	**Fe**	**Mn**	**Al**	**NH_4-N**
				----- % -----		mg kg^{-1}	--------------- cmol kg^{-1} ---------------					----------%----------			mg kg^{-1}
Brgy Centro 1 (lower)	4.45	3.71	3.58	0.96	0.09	1.24	0.18	1.21	1.26	2.14	4.61	5.2	1.2	0.8	35
Brgy Centro 1 (higher)	4.32	3.67	3.61	0.91	0.08	0.70	0.20	1.07	0.94	2.48	4.49	6.1	0.1	0.8	35
Brgy Centro 2	4.30	3.80	3.57	1.10	0.10	1.79	0.22	1.66	1.80	5.08	8.55	6.0	0.1	0.7	36
Brgy Kabisera 18	3.88	3.61	3.51	0.99	0.09	9.21	0.34	0.46	0.46	4.17	5.09	3.7	0.1	0.4	32

All samples had a sandy clay loam texture.

Table 6. Chemical surface layer properties of acid soils at selected upland research sites in Asia.

	pH	ORG.	BRAY 2	EXCHANGEABLE				EFFECTIVE
LOCATION	**in H_2O**	**C**	**P**	**K**	**Ca**	**Mg**	**Al**	**CEC**
		%	mg kg^{-1}	-------------------- cmol kg^{-1} --------------------				
Way Abung, Sumatra, Indonesia	4.71	-	4.8	0.11	0.46	0.31	0.87	1.75
Sitiung, Sumatra, Indonesia	5.11	2.7	0.8	0.09	1.29	0.30	0.82	2.49
Cavinti, Laguna, Philippines	4.40	3.6	5.8	0.44	1.05	1.27	6.80	9.56
Claveria, Mindanao, Philippines	4.10	1.8	9.8	0.10	2.74	0.69	0.58	4.11

Source: Garrity *et al*., 1990

IRRI'S UPLAND RICE ECOSYSTEM PROGRAM: THE FUTURE OF UPLAND RICE
(Excerpts from *The IRRI Upland Rice Research Program*, External Program Management Review Briefing, 1997)

Seventeen million hectares of upland rice are grown annually worldwide, producing some 20 million tons. Rice is a major staple crop for upland farmers who are among the poorest in many parts of Asia, Africa, and Latin America. The total area supporting upland rice-based cropping is considerably larger because of rotation with fallow and other crops. The crop is grown alone or in diverse mixtures in shifting or permanent fields under a wide range of conditions of climate, slope, and soil type, often as a subsistence crop receiving few purchased inputs.

Reported upland rice areas have remained stable or have increased in some countries, including the major Asian producers Bangladesh, India, and Indonesia, but have declined for others such as Thailand, Philippines, and Myanmar (Table 1). Adding the Asian area (10.5 million ha) to the 3.7 million ha in Latin America and 2.8 million ha in Africa, it is apparent that upland rice remains a very important crop for the poorest people of the world.

Table 7. Changing areas of upland rice in Asia (from Pandey, 1996).

COUNTRY	1978/80	1991	CHANGE
	-----1000 ha-----		%
Bangladesh	858	875	+ 2
India	5973	6330	+ 6
Indonesia	1134	1121	- 1
Malaysia	91	76	-16
Sri Lanka	52	60	+15
Vietnam	407	504	+24
Cambodia	499	36	-93
Lao PDR	342	234	-32
Myanmar	793	290	-63
Philippines	415	126	-70
Thailand	961	52	-95
Total	11,525	9,704	-16

The variation in the importance of upland rice over time and across countries can be partly explained (Pandey, 1996) on the basis of population density and market access (Figure 1). Increasing population pressure pushes the farming systems to become more intensive and sedentary. Increasing market access moves the systems toward more commercial production of nonrice crops. Integrated rice-based systems, with high population pressure but limited market access, grow rice and a range of annual crops in more or less permanent gardens and are the dominant systems in Asia (70% of the upland area). These are a major focus for IRRI research. Priority is also placed on the newly-emerging extensive perennial-based systems (14% of area), where rice and other annual crops are grown under or near permanent plantations such as rubber, oil palm, and fruit trees, which are developing in countries such as Indonesia and Vietnam.

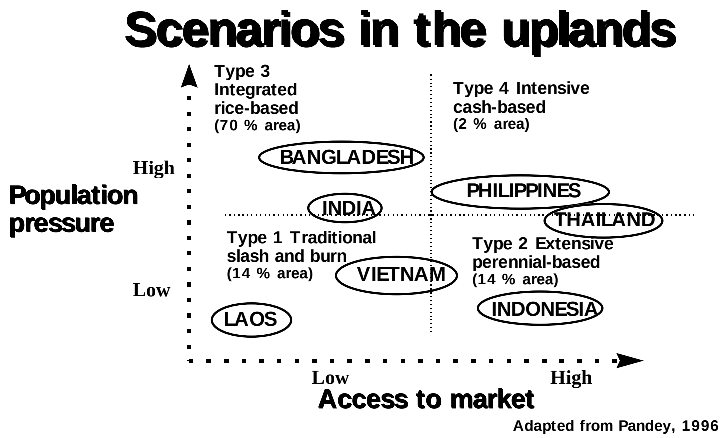

Figure 1. Characterization of upland rice systems according to market access and population.

Upland Rice Yields

Over the past 30 years, average yields of upland rice in Asia have risen slowly, increasing annually by 0.3% in India, 1.4 % in the Philippines, and 1.6 % in Indonesia. In contrast, increases have been much greater in irrigated systems, at around 2.5% in India and 3.2% in the Philippines (Fig. 2). This is a reflection of the enormous research effort that has been devoted to irrigated systems over the last 40 years, and the consequent wide adoption of improved germplasm that can express yield potential consistently under favorable irrigated conditions with high levels of inputs. In contrast, upland systems have received much less research attention, and much of the work that has been done has been of a more applied and site-specific nature.

The small productivity increases observed in the upland ecosystem may be largely because cultivation has been reduced in less favorable upland areas. There is little indication over most areas that input use has increased significantly, or that farmers are benefitting from the improvements in yield potential that have occurred as a result of variety improvement. In favorable environments (Brazil; Mindanao, Philippines), farmers are applying inputs and sowing improved varieties. In these areas, farmers cultivate larger or smaller areas in different years, depending on the market price of rice relative to other crops.

It is postulated that a more strategic research approach will provide essential understanding to underpin the development of more productive and sustainable upland systems. Given that IRRI is the lead CGIAR center in humid Asia, and rice is a staple in these upland systems, it is essential that IRRI maintains a role in this ecosystem. IRRI provides strategic research support to complement the more applied development efforts of the NARS.

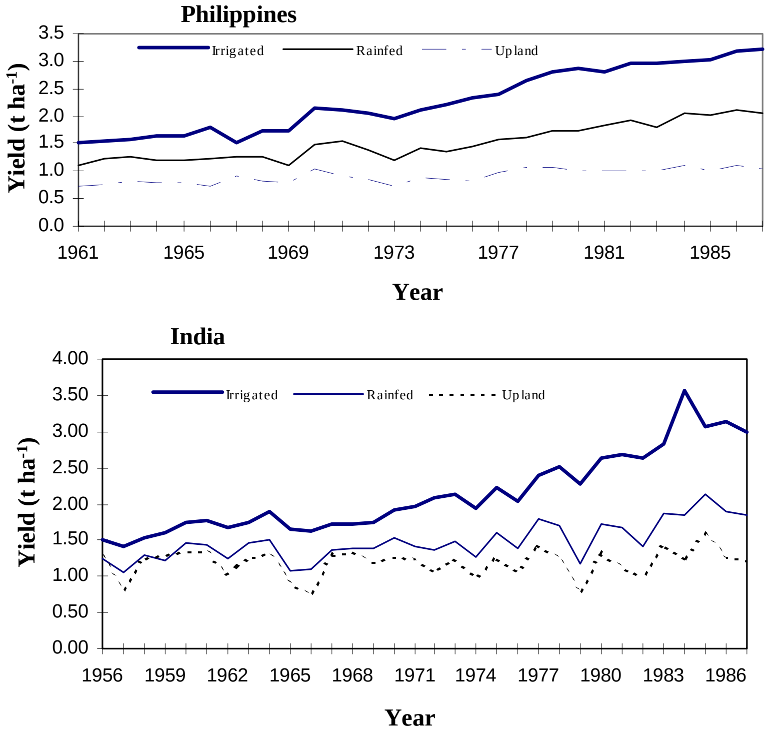

Figure 2. Trends in rice yields by ecosystem (IRRI Rice Statistics Data Base

Ecosystem Considerations in the Uplands

Sustainability issues

Erosion, deforestation, and burning are common features in upland systems, and degradation of soil and water resources can have severe adverse consequences on adjoining lowland ecosystems. Strategic research information on issues such as nutrient cycling, pest ecology, and sustainable rotations is limited for upland rice, and also for other crops grown in upland systems. In some countries, rehabilitation of enormous areas of degraded uplands is a priority—with upland rice an important component in the rehabilitation process. For example, in Indonesia, there is a program to rehabilitate 9 to 10 million hectares of *Imperata* grasslands using conservation farming (zero tillage and herbicides) of upland rice under developing oil palm and rubber plantations (A. Fagi, pers. comm. 1996). More strategic understanding of such rehabilitation systems is essential.

Equity, food security, and poverty issues

Equity issues compel us to attempt to improve conditions for upland farmers in Asia. Recent IFPRI studies (Fan and Hazell 1997) show that the marginal returns from government investments in technologies and infrastructures are now larger in rainfed areas than in irrigated areas. Rural poor are concentrated in rainfed areas, and poverty reduction in these areas has been relatively small.

Investment in improving the productivity of food crops in the uplands can be justified on the grounds of food security, poverty alleviation, and equity—all major platforms of the CGIAR. The national programs in countries with significant upland areas recognize this, and have developed upland research and development groups that look to IRRI to provide research collaboration, support, and training.

Water scarcity

As water becomes increasingly scarce in the irrigated lowlands, it is likely that some areas with light-textured soils will be forced to move away from paddy rice to systems of restricted irrigation. Considerable water savings will be possible if we transform rice into a truly aerobic crop. Research on genetics and physiology of drought tolerance, now being conducted in the upland program, will provide a strong strategic base for the future development of varieties adapted to a restricted water supply.

Research Opportunities in Upland Rice-based Systems

Where are the research opportunities to improve the productivity, profitability, and sustainability of upland rice-based systems? The low yield of upland rice has been attributed mainly to insufficient and irregular moisture supply, heavy weed infestation, lack of suitable varieties, nutritional imbalance, inadequate cultural practices, and inefficient control of insect pests and diseases. Arraudeau (1994), in a survey of researchers conducted in 36 countries representing approximately 90% of the upland rice area in the world, reported that the major abiotic constraints were drought, P deficiency, and soil acidity, and the major biotic constraints were weeds, blast, brown spot, and stem borers. Roder et al (1995) reported that farmers in Lao PDR considered weeds, rodents, insufficient rainfall, land availability, and insects to be the major constraints to upland rice production. Widawsky and O'Toole (1990) reported that yield losses of upland rice in eastern India were attributed mostly to drought, weeds, acid soils, and blast.

IRRI has combined this information on constraints with our emerging understanding of factors affecting land use patterns to set the research agenda for upland rice. For example, germplasm improvement is focused as illustrated in Figure 1 on the integrated rice-based (Type 3) and extensive perennial-based (Type 2) systems. Nutrient management research is targeted on areas where slopes are not too steep and rainfall is more reliable.

The IRRI Upland Rice Program

Although IRRI has undertaken upland research for many years, it has only been since 1990 that a critical mass of scientists has been assembled in a program framework in which a more strategic approach has been taken to understand and overcome the major constraints of the ecosystem. Donor support for the program is very strong. Of 8.1 scientist-equivalent positions in the program in 1997, only 1.8 are supported with core IRRI salaries. The majority of the scientists (6.3 persons) is supported by partners and donors (DANIDA, GTZ, USAID, Japan, CIRAD, ORSTOM), who are working on restricted core projects from the approved IRRI research agenda. Thus, some 80% (US$560 000) of the US$700 000 operating budget for the upland program is provided by donors to support these restricted projects. This tremendous outside support is a strong recognition of the pivotal international role IRRI plays in providing strategic support for efforts of NARS to develop productive and sustainable farming systems in this difficult upland environment.

The major thrust of the program is to develop understanding and technology to maximize productivity and sustainability of upland rice where it is grown, to help maximize returns for farmer effort, and reduce the area needed to satisfy demands for upland rice. Many studies are also providing scientific understanding with broad application outside the upland ecosystem. The program is not promoting expansion of upland rice, although it is recognized that rice areas in the uplands will fluctuate with market forces.

The program has several major themes. One is on germplasm improvement to overcome the major abiotic (drought, nutrient availability, acidity, erosion) and biotic (weeds, blast, nematodes) constraints, moving away from traditional breeding and selection and using new technologies to target, characterize, and incorporate desired genes. There are two novel projects on development of perennial rice for the uplands: 1) to help erosion control and food security and 2) to investigate allelopathy in rice to assist with sustainable weed management. The perennial rice and allelopathy projects are also providing valuable information on genetic characterization of rice and its wild relatives and the genetics and physiology of tolerance to such constraints as drought and nematodes.

The second theme is on abiotic constraints, focusing on a strategic understanding of nutrient availability (P, N, OM, soil acidity) in upland soils. The third theme is on biotic constraints, investigating the biology and management of weeds, nematodes, and blast. Underpinning these themes is a study of the socio-economic of the uplands, which is designed to characterize and understand the dynamics of the systems and the impact of new technologies and policies.

The Upland Rice Research Consortium and Other Collaborations

The program is implemented in close partnership with NARS partners through the Upland Rice Research Consortium (URRC). The consortium, which has been in operation since 1991 with continued support from ADB, GTZ, and Japan, provides a framework for NARS-IRRI collaboration, and focuses on strategic issues and themes of importance to the upland ecosystem. For example, nutrient management in the infertile and acid uplands is a theme and sites/countries where nutrient research is done under the consortium is presented in Table 7. Each partner focuses on a theme and shares outputs with others—so the sum of the parts is greater than the whole. It is important to emphasize that the partnership is an equal one, where all share in the planning, implementation, and reporting of the research agenda. Consortia have been described in detail in a separate EPMR briefing paper.

The IRRI upland program also has linkages with:

- The Ecoregional Initiative for the Humid and Subhumid Tropics and Subtropics of Asia (ECORI), coordinated by IRRI, and the associated Soil Erosion Consortium convened by IBSRAM, which provide inputs on a range of issues including appropriate upland technology, socio-economic, and erosion
- The IRRI country project in Lao PDR, which provides technical support on such issues as germplasm improvement, pest and weed management, and soil improvement. The Lao-IRRI project has one full time agronomist based in Luang Prabang working on the improvement of upland-rice based production systems in northern provinces.

  In the uplands, the Lao-IRRI Project focuses on:
  - Characterization of upland farming systems with surveys of farmers practices and of household economic status;
  - Stabilization of shifting cultivation systems through fallow improvement and rotation management to control erosion, maintain soil fertility and reduce labor requirement for weeding;

    - Collection, evaluation and selection of traditional glutinous and nonglutinous upland rice varieties; and
    - Yield loss assessment from pests and diseases and development of appropriate IPM technologies.
- The CIAT Forages in Asia Project, headquartered at IRRI, conducts collaborative studies on forage-crop interactions in the Philippines.

Table 8. Nutrient Management Research in the Upland Rice Research Consortium[a]

EXPERIMENTS	COUNTRY						
	BRAZIL	INDIA	INDONESIA	LAOS	PHILIPPINES	THAILAND	VIETNAM
Long-Term P Exp. (LTPE)		X (1995)	X (1994)		X (2)[b]	X (1995)	X (1998)
Subsoil acidity			X (1994)				
Nutrient (N&P) x water		X (1995)			X (5)[c]	X (1996)	

[a] Numbers in parentheses denote year in which the experiment started

[b] I) Siniloan (1995) and ii) Matalom (1994)

[c] I) IRRI upland farm (1995), ii) Batangas (1995), iii) Cavinti (1995), iv) Matalom (1995), and v) Arakan Valley (1997)

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SUMMARY OF GROUP DISCUSSIONS AND WORKSHOP OUTCOMES

INFORMATION NEEDS FOR ACIDITY, N AND P DECISION SUPPORT COMPONENTS

ADSS

Discussions focused on how to obtain and structure information on three tasks: (1) prediction of lime movement; (2) diagnosis and correction of Ca & Mg deficiencies/Mn toxicities; and(3) prediction of organic matter effects on acidity. The kinetic portion of Bouldin's ionic balance model was deemed an important tool for investigating lime movement. We need to find suitable data sets for a variety of conditions to use with the model. These data sets should include soil solution ionic composition and exchangeable cations with profile depth and across time. Preliminary investigations suggest that NO_3 adsorption in subsoils with variable charge characteristics would help interpret cation movement after liming. This information should also be of interest to evaluations of N losses and fertilizer N efficiencies by the NDSS component.

Literature needs to be searched for multi-location data related to changes in soil acidity and Mn upon additions of organic materials. Eventually, we want to predict liming equivalency of organic amendments under various soil combinations and source of organic materials.

A group effort in literature searches should lead to compilation of information in an electronic format. The focus of the search should be on multiple factors: Al & Mn toxicity, Ca & Mg deficiency, lime movement and organic amendment effects. The following table describes criteria for "filtering" the literature and compiling the electronic database:

ESSENTIAL INFORMATION		DESIRABLE AUXILIARY INFORMATION	
1.	Lime source - Ca & Mg added; total neutralizing power; particle fineness measures	1.	Management practices - method of lime application; depth of application; fertilizers added to each crop; crop management
2.	Soil data - pH, KCl-extractable Al, Ca & Mg; exchangeable K; extractable Mn; at one or more sampling dates after liming	2.	Details on soil analytical methods - extractant; agitation time; soil:extractant ratio; procedures for element determinations
3.	Weather data - daily, weekly, monthly precipitation at the site or access to adjacent weather stations	3.	Soil analytical data with profile depth at several times after lime material application
		4.	Crop yields (grain and stover)
		5.	Soil profile description

NDSS

Discussion focused on information needs for the algorithm used to predict fertilizer N (Fert. N) requirements for a targeted crop yield (Y):

Fert. N=(Y%N)-[Soil N+(animal manure N/Eff)+(green manure N/Eff)+(residue N/Eff)]/Fert. Eff.*

where:
(Y*%N) = aboveground N accumulation by the crop at the targeted yield level;
Soil N = the portion of plant accumulated N coming from soil reserves, primarily soil organic matter; and
Eff. = efficiencies at which a crop is able to use N each supply pool (animal manure, green manure, crop residue and fertilizer).

Prior experiences indicate that soil organic matter is a good indicator of soil N supply over the long term, but overestimates for the short term. The best estimate of soil N supply is expected from yields without applied N. The existing algorithm needs to be adjusted to account properly for BNF contributions. Differences among climatic regions can be accounted for through use of different efficiency factors for the various N supply pools.

Fertilizer N recommendations need to focus on the minimum requirements to achieve desired product yield. Default values for the fertilizer N algorithm need to compiled for location specific conditions. This implies an extensive group effort in reviewing existing literature. Varietal differences need to be accounted for whenever indicated by information from the literature. A group effort will be initiated to compile literature information using a specific format. Compiled literature data could be assembled on the project's Web site for access by all group members. A list was developed for the crops for which information was needed.

Experiments initiated in year 2 at the intensive testing sites need to include designs which provide information needed in years 3 and 4 for scheduled activities on BNF and legume management. Treatments should include factorial combinations which address the interactions of P and acidity with N.

Upon completion of the baseline assessment of intensive testing sites, the group proposes to hold a second meeting with acidity and P representatives to update and continue discussions initiated at this workshop.

PDSS

Current conditions in each of the three intensive testing sites were evaluated and related to planned tasks for P in the project. Needs in Costa Rica vary with types of producers (small vs. plantation), crops (grain, export, vegetables and flowers), and soil type (i.e. clay mineralogy). PDSS presently cannot predict how much P to apply for each of these conditions, thus, indicating a need to refine P coefficients for all soils.

In the Philippines the system should help determine proper P fertilization rates, as opposed to existing blanket recommendations and use of standard NPK ratios. Correction of P deficiencies and even applications above the recommended optimum could help improve soil quality and expand cropping alternatives.

Research is in progress in Mali to evaluate soil P coefficients. Although it is currently in high demand, there is no data available in the country for cotton. Tasks for evaluation of phosphate rock should begin soon and, perhaps, include considerations as an investment to be pro-rated over several crops. PDSS should also help justify establishment of millet/fertilizer P price ratios required for P fertilization to become an economical option with millet production.

The overiding emphasis of discussions was on refinement and expansion of the P coefficients. The group felt that tasks for the diagnosis and recommendation of P for tree crops, and evaluation of soil conditions suitable to phosphate rock applications should begin as soon as possible. The group gave a low priority to the tasks for evaluating recommendations for localized P fertilizer placement.

INFORMATION NEEDS FOR THE INTEGRATED DSS MODULES

Diagnosis

The group reviewed the paper prototypes Deanna Osmond presented in plenary for the Diagnosis module. The following recommendations represent group consensus for clarifying and improving the ability to manage user-input information for this module.

- a GIS interface with rainfall isolines and/or agroecological zones might be helpful when asking for information about where the crop will be grown;
- the current crop database was grouped into three tiers, ranked by decreasing importance with respect to food security; these are (in decreasing order): Tier 1 - maize, millet, peach palm, sorghum and upland rice; Tier 2 - cassava, cowpea, peanut, *Phaseolus* beans, potato, soybean and wheat; Tier 3 - coffee, sugar cane and cotton;
- use U.S. Soil Taxonomy for soils information;
- allow for input of site specific rainfall and rooting depth, if known;
- in cropping history consider inputs for intercropping system and fallow period;
- for factors limiting previous crop yield, include plant stand and planting date; expand weather-related problems to include rainfall and temperature extremes;
- for organic inputs under prior fertilization allow for whether material was left on the surface or incorporated;
- for users unable to estimate organic inputs, consider other indices (surface cover, depth on surface, height of cover crop) as well as nutrient concentrations;
- include % sand and soluble salts under soil chemical information, and exclude total N; and
- separate soil chemical and physical information requests via columns or boxes for each.

Prediction

Discussion focused on information needed to provide a recommendation for acidity, N and P constraints. The basic need for all three constraints is the development of tables, matrices or algorithms which will predict the change in crop yield upon correcting the soil constraint. It was assumed that the diagnosis component would assemble appropriate information on soil and climate characteristics. Desirable soil factors include texture, slope, organic matter, mineralogy, root-growth barriers, drainage and erosion hazard. Climatic factors include rainfall quantity and distribution, and evapotranspiration. Desirable information and recommended measures are described in the following for each DSS component.

ADSS -

- % Al saturation for obtaining 95% of maximum yield on each crop species. Predictions require user input of exchangeable Al in the soil. An alternative measure to Al could be soil pH and texture, but it is very region-dependant and there was skepticism as to how good a diagnosis/prediction could be derived from such data.
- residual effects of lime. The most desirable information set includes precipitation, source and amount of fertilizer N, pH, texture and clay content. The second best data set would be only precipitation with interpretations on the basis of regional “wisdom”.

PDSS -

- relations between crop yield and soil test P for each crop species. The most desirable information would be yield-soil test P calibrations for each crop and major soil type. The second best information would be soil test calibrated for yield “response” and “no response” to applied fertilizer P.
- questions arise as to what can be done in predictions when no soil test P data is available. It is a matter as to how far can the soil test data be extrapolated on the basis of soil and crop characteristics.

NDSS -

- Nitrogen in aboveground dry matter and harvested roots-tubers for each crop species;
- Nitrogen supplied by the soil reserves. The best estimate would be yields without applied N. The second best estimate would be based on past additions of manures and crop residues (a crude estimate of “active” soil organic matter based on local wisdom). The poorest estimate would be from correlations with organic N or organic matter.
- Predictions with the pre-sidedress N tests should be investigated, given their increased adoption in temperate regions.

Fertilizer Guidance

Discussions were related to how economics, science and conceptual approaches in support system design are merged to provide recommendations on fertilizer use. The group recognizes that IntDSS will eventually be used at different scales of farming (small, plantation, corporate, etc.) and feels that crop response to a recommended action to overcome a nutrient constraint is independent of user attributes. However, the intended user will decide whether to follow or modify these recommendations. Major items of discussion are outlined in the following general and specific concerns:

- The current data base is heavily biased towards annual crops. Information can be added for other crops, but someone has to provide the necessary information to those developing the support system.
- Total dry matter yield may be just as important as grain yield in some regions, due to the high value of crop residues as fodder. This could be incorporated into IntDSS by adding options for prediction and fertilizer guidance on grain, forage or total biomass. This may be best achieved by including consideration of crop harvest indices.
- Distinction between acidity and Ca-Mg deficiencies may need strengthening in ADSS. This has relevance to how much lime is recommended. For IntDSS it would be important to include estimates of soil acidification resulting from N applications.
- Development of the first IntDSS prototype includes assembly of acidity, N and P DSSs under a common shell, but does not involve interactions between these nutrient constraints. Nutrient interactions need to be included in intensive testing site experiments in anticipation that this information will be included in subsequent IntDSS prototypes. Likewise, literature searchers need to be looking for this kind of information.
- Tasks to implement fertilizer guidance on residual effects of P and lime are planned for project years 3 and 4. Therefore, evaluation of these factors need to be initiated at intensive testing sites as soon as possible.

INFORMATION NEEDS FOR INTENSIVE TESTING SITES

Costa Rica

Despite differences in soil constraints, climate and cropping systems among sites, there is a need for standardizing some procedures. In soil sampling and analysis this could include number of samples per treatment and sampling depths, extraction procedures, soil characterization, and achieving selected samples from each site for yet undetermined use. Weather and light conditions need to be characterized so explanations can be based on plant growth characteristics as well as soil conditions.

Primary focus of the site is on heart of palm production with peach palm on acid soils derived from volcanic materials in a perudic environment. Suggested investigations reflect the limited information base for nutrient management of this commodity, as well as diagnosis and prediction for acidity, N and P constraints in these types of soils.

- Plant residue accumulation and its role in nutrient cycling and acidity management. Under mature peach palm plantations layers of organic material can be as thick as 10-15cm. Empirical information could be obtained by sampling sites with known management history to characterize this build-up of organic materials. This information would be relevant to acidity, N and P management.
- Nutrient accumulation in peach palm with plantation age. Destructively analyze peach palm aboveground biomass for dry matter and nutrient content in fields with different ages. This would give information on nutrient requirements with plant age from establishment to maturity (or time where production reaches and equilibrium, i.e. 4 years).
- Preliminary liming experiment. Grow seedlings in soils with different lime treatments. Measure root length response and develop relations between lime, pH and %Al saturation. This would help determine how well the % Al saturation concept works in these Andisols and the extent of Al tolerance and Ca requirements for peach palm.
- Lime response curve. Include treatments with 0 - 6 t of lime/yr. Compare lime sources and timing of lime application. Isolate effects of Ca, Mg and acidity neutralization. Monitor lime movement over time and differences in root proliferation.
- Variable rates of N, P and K with constant lime supply. This would be a long-term experiment to establish fertilizer responses with plantation age (it is expected that fertilizer needs for crop establishment may be quite different from nutrient maintenance once the crop reaches an equilibrium in growth and production).

Mali

Farming in the Cinzana region is on Alfisols with a sandy surface layer that is acidified under continuous cropping. Rainfall is monomodel and 600mm per year. Farming on the sandy soils consist of continuous millet-cowpea intercropping in 65% of the area. In the remaining 35% of the area, with loamy soils, farming consists of continuous sorghum/cowpea intercropping with some other crops.

Farmers identify soil quality based on texture and slope position. Nutrient inputs are solely organic and include livestock manure, household manure and nomadic herd grazing on crop residues after grain harvest. Potential nutrient inputs include locally available Tilemsi PR which could be applied directly to fields or mixed with manure composts. Dolomitic and calcitic lime sources are available in Mali.

IER plans to conduct on-farm trials with PDSS and NDSS. These trials consist of two locations in the Cinzana region, each with 3 farmers using a millet/cowpea intercropping system. Treatments include comparisons of compost versus no compost applications. Subtreatments include crop genotypes and planting dates.

Information is also available from past and ongoing SM-CRSP collaborative studies. These investigations address interactions between N, water and tillage, and N and P interactions within various cereal/legume crop rotations.

Other areas meriting additional investigations include:

- N use efficiency from compost when surface applied or incorporated;
- Effects of organic amendments on surface soil acidity, and Ca & Mg deficiency;
- Contributions of BNF within N, P, and acidity (lime) interactions; and
- Expansion of IntDSS testing to cotton production in wetter regions (1000-1200 mm) of Mali. Chemical fertilizers (41-31-24 NPK) are applied only to cotton which is grown in a 3 year rotation cycle of cotton-maize-sorghum.

Desired measurements, protocol and analytical determinations need to be defined for field, soil and plant sampling at the Mali site.

Philippines

Experiments are needed at all intensive testing sites which allow both evaluation of predictions by the existing ADSS, NDSS and PDSS modules, as well as acquisition of information on N, P and lime interactions for the future IntDSS software. Preliminary design for the three factor N, P and lime experiment in the Philippines should include the following:

- Two side-by-side cropping system rotations, with rice and peanut in the first year followed by corn and soybean in the second year;
- Two levels each of N, P and lime;
- Monitor residual effects of lime and P;
- Plant sampling of total biomass at harvest and diagnostic tissues for nutrient content; and
- Soil sampling at the start of the experiment and after each crop harvest at depths of 0-15, 15-30, 30-60 and 60-90 cm.

Other site-specific experiments would include the following:

- Single factor rate experiments to develop soil test - yield response curve calibrations;
- Lime experiments including gypsum applications to evaluate Ca movement and improvement of crop root proliferation; and
- Organic amendment effects on Al chelation.

A group needs to be identified for each intensive testing site with responsibilities to assure continuity and quality of on-site activities. (*Assemblers editorial note:* this recommendation strengthens and expands the existing project structure wherein a U.S. scientist has been delegated the responsibility of coordinating all project tasks at each site among U.S. team members. These coordinators are Lloyd Hossner (Texas A&M) for Mali, Jot Smyth (N.C. State) for Costa Rica, and Russell Yost (Hawaii) for the Philippines).

OTHER WORKSHOP CONTRIBUTIONS AND GENERAL OUTCOMES

In both their individual comments and discussion group reports, project team members repeatedly emphasized the importance and value of face-to-face interactions with the rest of the team as a process for fine tuning our 5-year workplan and understanding how each participant's tasks contribute to the targeted decision support products. The group working on the N component have already determined the need for a second meeting in the first half of the project's second year to review and exchange information collected in their search of existing literature, and adjust procedures, if necessary, for continuation and completion of this multi-year task.

Team member discussions on topics presented during plenary sessions provided necessary input for continuation or completion of several ongoing project tasks. Adjustments were made to several components of the proposed IntDSS structure (Figure 1) which allowed subsequent initiation of the actual programming of the Diagnosis, Prediction and Fertilizer Guidance modules for the initial prototype. In the Diagnosis module decisions were made on what information will be requested from users, how questions will be asked, as well as the order in which they will be asked. This subsequently clarified the structure of the databases and types of information which need to be gathered in literature searches.

A big challenge in the design and development of the Prediction and Fertilizer Guidance modules is how to structure solutions for users who, for various reasons, might choose to use N, P and/or lime at less than the recommended optimum levels. Russell Yost proposed a format for assessing multiple nutrient interactions (Figure 2) which serves as a workable target for designing these modules and clarifies the type of nutrient interaction data we should try to obtain through field trials at the intensive testing sites.

Frank Smith surveyed team members during the workshop with a questionnaire designed to identify information they deemed useful in either formulating decision aids, planning research and extension activities, or measuring program impact at the intensive testing sites. This information was then used in planning and designing the baseline assessment surveys which were conducted at the intensive testing sites in Costa Rica and Mali after the workshop.

At the end of the workshop it was agreed that field experiments and investigations needed to be designed and implemented as soon as possible at the intensive testing sites. Project coordinators were delegated the task of designing these field activities, based on outcomes of workshop discussions and in consultation with intensive testing site collaborators. It was also apparent that the types of multi-year investigations planned for the intensive testing sites could not be sustained with the original annual budget ($7,300) earmarked for each site in the project proposal. To guarantee availability of funds for intensive testing site activities, project members agreed to set aside in each fiscal year the necessary budget to support site activities. This will be done by means of an equitable reduction in funding for each team members designated tasks. Since most of the team member tasks involve activities at the intensive testing sites this only constitutes a redistribution in project funds to facilitate project support of operations at each site. Details on experiments and budgets for each intensive testing site will be included in workplans for the second year of the project.

AKNOWLEDGEMENTS

Our special thanks to the University of Hawaii, the SM-CRSP Management Entity office, and Agronomy Department's faculty, staff and graduate students for hosting this workshop, coordinating logistics, providing excellent on-campus facilities and transportation between hotels and meeting sites.

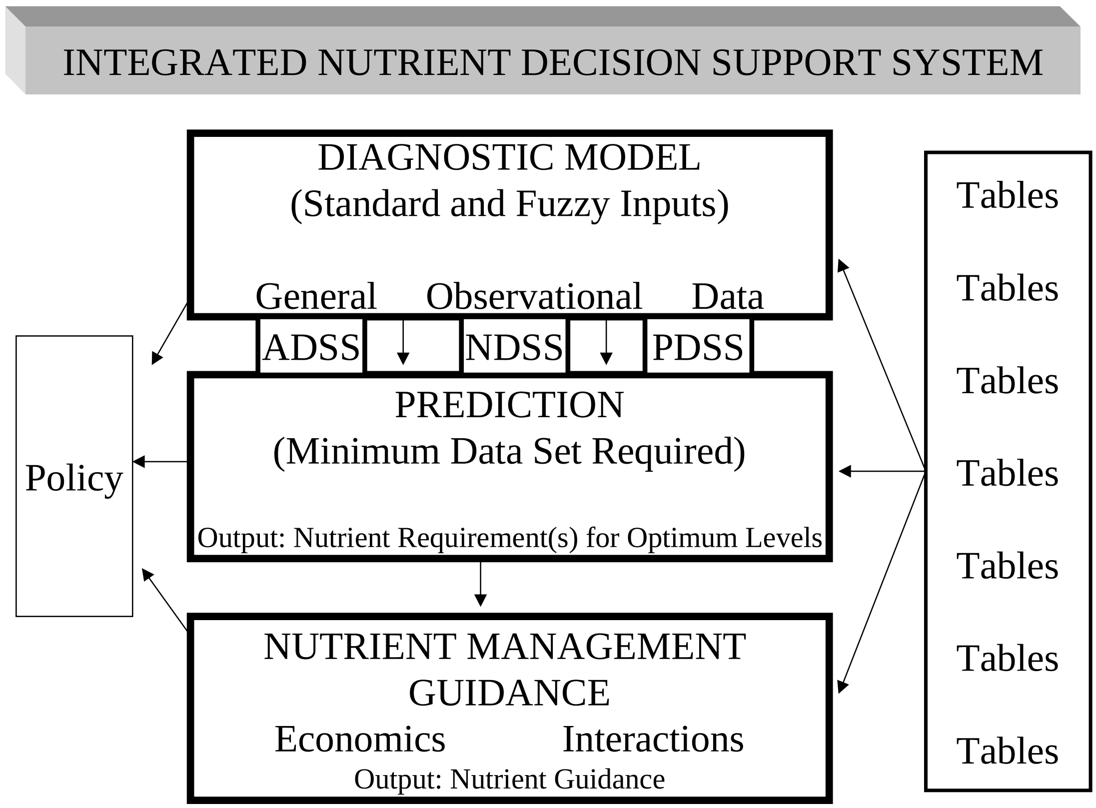

Figure 1. Linkages between modules, databases and individual decision support systems in the initial prototype of the Integrated Decision Support System (IntDSS).

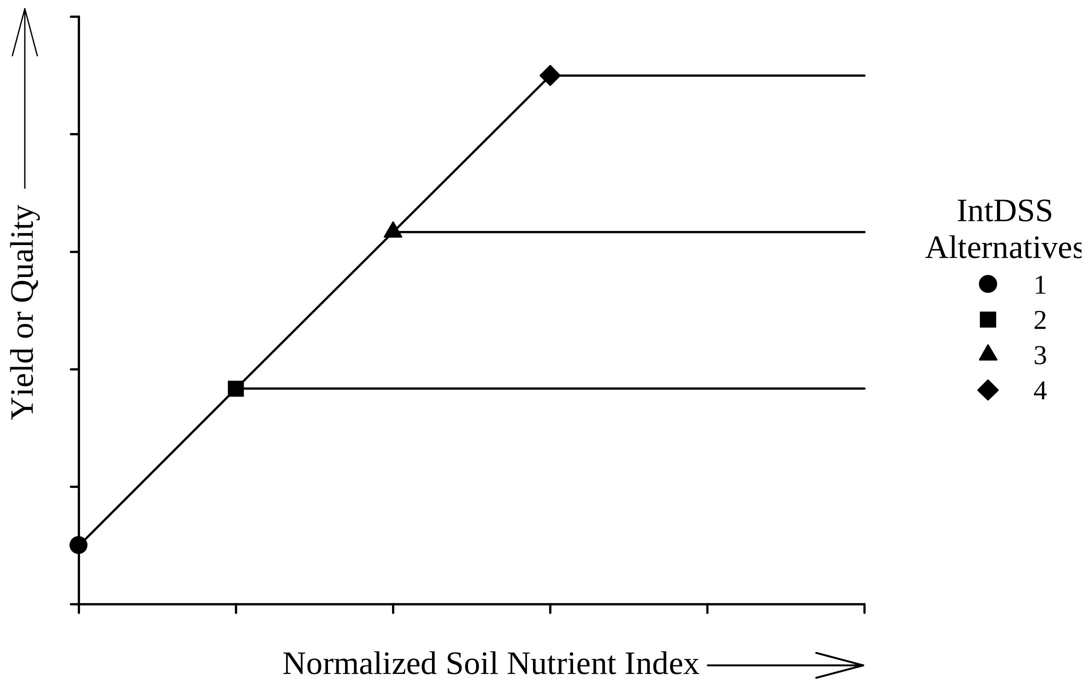

Figure 2. Graphical format for presentation of IntDSS nutrient interactions. Alternatives correspond to different combinations of normalized soil nutrient levels for N, P and acidity. Graphical presentation would be complemented with data shown in Table 1.

Table 1. Proposed data output for comparisons between recommended alternatives by IntDSS and user selected inputs. Alternatives and their factor levels correspond to combinations of N, P and acidity correction to achieve normalized nutrient indexes shown in Figure 2.

RECOMMENDED	**N, P & LIME FACTORS**			**PREDICTED**		**BENEFIT:**
ALTERNATIVES	**F1**	**F2**	**F3**	**YIELD**	**COST**	**COST**
1	0	0	0	Y1	Z1	Y1/Z1
2	X1	0	0	Y2	Z2	Y2/Z2
3	X2	X3	0	Y3	Z3	Y3/Z3
4	X4	X5	X6	Y4	Z4	Y4/Z4
5	user selected inputs and predicted yields					

Appendix 1
Workshop Participants, Affiliated Institutions and E-mail Addresses

NAME	INSTITUTION	E-MAIL
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Russell Yost	University of Hawaii	rsyost@hawaii.edu

Appendix 2 - Workshop Program
Decision Aids for Integrated Soil Nutrient Management
Krauss Hall, University of Hawaii
Honolulu, Hawaii
December 1 - 3, 1997

TIME	TOPIC	RESPONSIBLE	TYPE	DESCRIPTION
Monday, December 1				
8:00	Welcome to UH	Dean Laughlin	Plenary	
8:10	Soil Management CRSP & Decision Aids Proj.	Uehara	Plenary	CRSP composition; how projects should operate; expected interaction between projects
8:30	Project Overview	Smyth	Plenary	Details of project development, its current structure, its progress to date
9:00	Logistical instructions for workshop	Tsuji	Plenary	Details of schedule, meal arrangements, hotel, registration etc.
9:15	Questions & Comments		Plenary	
	Intensive Testing Site Presentations			Characterization of natural resources, economics, and social conditions at each; what is needed in soil nutrient management
9:30	Costa Rica	Alvarado	Plenary	
10:00	Coffee / soft drink			
10:15	Mali	Doumbia	Plenary	
10:45	Philippines	Corton/George	Plenary	

TIME	TOPIC	RESPONSIBLE	TYPE	DESCRIPTION
11:15	Testing site baseline and impact assessment	Smith	Plenary	Present ideas on how to do; raise questions about different approaches that could be followed
11:45	Questions & Comments		Plenary	
12:00	Lunch			
1:00	DSS Integration	Osmond	Plenary	Prototype for merging the 3 DSSs; how it will be done over 5 years
	Current Status & Future Needs of Each DSS; *Cross-cutting activities*			Current model and their planned improvements; IntDSS cross-cutting components
1:20	ADSS	Smyth	Plenary	
1:40	NDSS	Reid	Plenary	
2:10	PDSS	Yost	Plenary	
2:30	Coffee / soft drink			
2:45	Predicting residual lime effects	Bouldin	Plenary	
3:05	Predicting residual P effects	Cox	Plenary	
3:25	Organic soil amendment effects	Hue	Plenary	
3:45	Questions & Comments	Osmond	Plenary	
4:15	Africa InterCRSP Project	Kablan	Plenary	Nature of the project; linkage to the IntDSS project; how we can assist through our planned activities

TIME	TOPIC	RESPONSIBLE	TYPE	DESCRIPTION
Tuesday, December 2				
8:00	Form groups / outline group work		Plenary	
8:15	*Group Discussions on How to Achieve Individual DSS Improvement*	Moderator & Rapporteur for each group	Three Groups	One group for each DSS, wherein the planned improvements are discussed as to how they should best be done; categorize what will be done by campus-based, int. testing site, and extensive evaluation
10:00	Coffee / soft drinks			
	Auxiliary tools for IntDSS			Description of what they do & how they work
10:15	Lime spreadsheet	Yost	Plenary	
10:45	Nitrient budget spreadsheet	Reid	Plenary	
11:15	Ideas on other potential auxiliary tools	Robotham	Plenary	
12:00	Lunch			
	DSS Group Reports	Smyth		
1:00	ADSS	Rapporteur	Plenary	
1:20	NDSS	Rapporteur	Plenary	
1:40	PDSS	Rapporteur	Plenary	

TIME	TOPIC	RESPONSIBLE	TYPE	DESCRIPTION
	Components of the Integrated DSS			Description of the prototype; needed information
2:00	Diagnosis	Osmond	Plenary	
2:30	Prediction	Yost	Plenary	
3:00	Coffee / soft drinks			
3:15	Fertilizer Guidance	Osmond	Plenary	
3:45	*Group Discussions on How to Achieve the Needed Information for IntDSS Components*	Moderator & Rapporteur for each group	Three Groups	One group for each component, wherein the component development is discussed and sources of information and their use are identified; categorize sources as campus-based, int. testing site, and extensive evaluation
5:00	Adjourn			

TIME	TOPIC	RESPONSIBLE	TYPE	DESCRIPTION
Wednesday, December 3				
	IntDSS Component Group Reports			
8:00	Diagnosis	Rapporteur	Plenary	
8:20	Prediction	Rapporteur	Plenary	
8:40	Fertilizer Guidance	Rapporteur	Plenary	
9:00	Intensive Testing Site Needs	A representative from each of the 3 sites	Plenary	
9:30	The process of testing, refining & re-testing IntDSS at intensive testing sites	Yost	Plenary	How this should work; pitfalls to avoid; success stories from the past; etc.
10:00	Coffee / soft drink			
10:15	*Group Discussion on Testing Site Activities for IntDSS testing / refining*	Moderator & Rapporteur for each group	Three Groups	One group for each site; to consider field trials that might be needed; how planned priority research tasks for individual DSS modules can be incorporated
12:00	Lunch			
	Group Reports on IntDSS	Osmond		Includes report & discussion for each site
1:00	Costa Rica	Rapporteur	Plenary	
1:30	Mali	Rapporteur	Plenary	
2:00	Philippines	Rapporteur	Plenary	

TIME	TOPIC	RESPONSIBLE	TYPE	DESCRIPTION
2:30	Discussion of recommended activities across sites		Plenary	
3:00	Coffee / soft drink			
	Extensive Evaluation Network			
3:15	The planned network activities	Frank	Plenary	Description of workshops with network participants & individual travel to interact with participants
3:30	Suggestions for improvement & modifications of planned activities		Plenary	
3:45	Project modifications arising from the SM-CRSP BOD Meeting	Smyth	Plenary	
4:00	Schedules & deadlines for Workplans & Annual Budgets for Year 2	Tsuji	Plenary	
4:30	Adjourn			

Appendix 3
Discussion Group Participants, Moderators and Reporters

DISCUSSION GROUP	PARTICIPANTS
Acidity DSS Component	Bouldin, Corton, Coulibaly, Hue, Juo, Kablan, Salas[b], Smyth[a]
Nitrogen DSS Component	Hons, Israel, Osmond, Reid[a], Wagger, Wollum[b]
Phosphorus DSS Component	Alvarado, Cox[b], Doumbia, George, Yost[a], Wang
IntDSS Diagnosis	Coulibaly, George, Hue, Kablan, Osmond[a], Wagger[b], Wollum
IntDSS Prediction	Bouldin[b], Cox, Corton, Hons, Salas, Yost[a]
IntDSS Fertilizer Guidance	Alvarado, Doumbia, Israel[b], Juo, Reid[a], Smyth
Costa Rica Site	Alvarado[a], Bouldin, Osmond[b], Salas, Smyth
Mali Site	Coulibaly, Doumbia[a], Hons, Hue, Israel, Juo[b], Kablan, Reid
Philippines Site	Cox, Corton[b], George[a], Robotham, Wagger, Wollum, Yost

[a] Group moderator
[b] Group reporter